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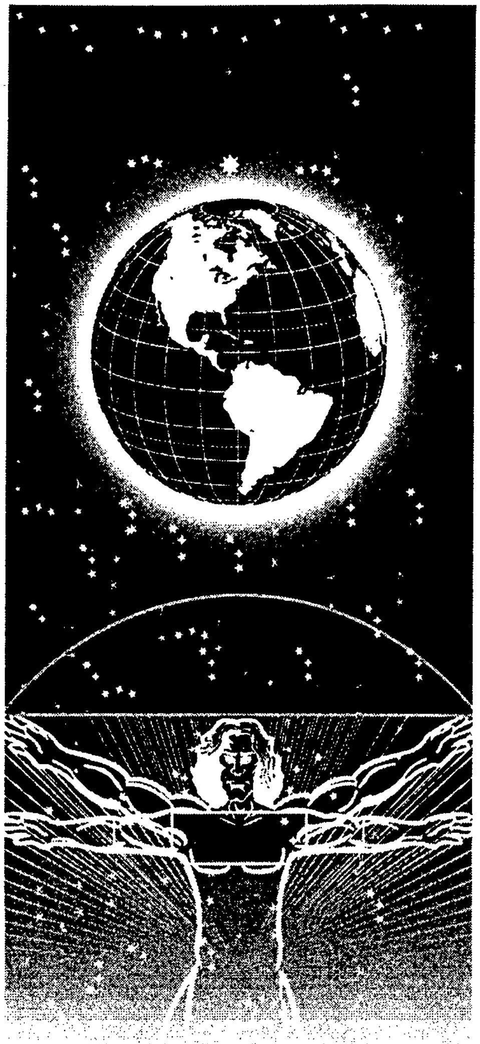

UNITED STATES AIR FORCE
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Lakehurst Naval Air Engineering Station (NAES) Radiological Baseline Survey in Support of USAF BOMARC Missile Accident Site Remediation Waste Transportation Plan, New Jersey

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13. ABSTRACT *(Maximum 200 words)*
The BOMARC Missile Site contains weapons grade plutonium (WGP) as the result of a nuclear weapon accident that occurred in 1960. This report documents a background radiological survey conducted in support of the truck transport and rail transfer of radiological waste from the USAF Boeing Michigan Aeronautical Research Center (BOMARC), Fort Dix, N.J. through Lakehurst Naval Air Engineering Station (NAES), N.J. to rail facilities connecting to the NAES. The survey was conducted from 9 - 10 January and 8 - 9 April 2002, with respresentatives from AFIERA/SDR, Environmental Division of Lakehurst NAES, and Navy Radiological Affairs Support Office (RASO), Naval Sea Systems Command Detachment, Yorktown, VA. The survey consisted of in-situ gamma and alpha radiation measurements, and soil sampling. The soils were analyzed by high-resolution gamma spectroscopy analysis and isotopic plutonium through alpha spectroscopy. The results of the surveys were unremarkable and typical for background radionuclides. Plutonium concentrations ranged from (-7) to 80 femtocuries per gram (fCi/g), with a mean of 11.8 fCi/g.

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1. Introduction

This report documents a background radiological survey conducted in support of the truck transport and rail transfer of radiological waste from the Boeing Michigan Aeronautical Research Center (BOMARC), Fort Dix, N.J. through Lakehurst Naval and Engineering Station (NAES), N.J. to rail facilities connecting to the NAES. The purpose of the survey is to establish pre-existing radiological conditions for in-situ measurement instruments and analyses of soil samples, and establish laboratory and field performance expectations for the post-transportation sampling and analysis. In addition, the information contained in this report will be a vital aid to field survey and assessments in the unlikely event that an accidental release of BOMARC contaminated soils occurs during truck transport or rail transfer on NAES.

The survey described in this document was conducted from 9 - 10 January and 8-9 April 2002, with representatives of the Radiation Surveillance Division of the Air Force Institute for Environment, Safety and Occupational Health Risk Analysis (AFIERA), Brooks AFB TX; Environmental Division of Lakehurst Naval Air Engineering Station (NAES), N.J.; and the Navy Radiological Affairs Support Office (RASO), Naval Sea Systems Command Detachment, Yorktown, VA. Instrumentation from both AFIERA and RASO were used in the survey, while only the results from the AFIERA instruments are provided here. Soil samples were analyzed by AFIERA, with split samples sent to RASO and Framatome ANP, Inc. (formerly Duke Engineering & Services).

Between the transportation route and the rail transfer area (railhead), a total of 121 samples were analyzed by AFIERA. The γ-spectroscopy analyses were unremarkable, with positively identified radionuclides being naturally-occurring or from atmospheric nuclear weapons testing fallout. The isotopic plutonium analysis using α-spectroscopy found detectable concentrations of $^{239+240}Pu$ in the samples, but at activity concentrations below 100 femtocuries per gram (fCi g^{-1}). The concentrations of $^{239+240}Pu$ reported were within the range typical for fallout. Portable instrument measurements were typical for uncontaminated areas, with some variability that should be accounted for in field survey work accomplished during support of transportation operations.

2. Background

The BOMARC Missile Site is an inactive Air Force installation located in Plumstead Township, New Jersey. The site was an active nuclear missile defense site from 1958 – 1971. On June 7, 1960, a fire occurred in one of the shelters in which the shelter, missile, and warhead were partially consumed by the fire. The high explosive materials in the weapon ignited but did not detonate. The most intense period of the fire lasted about one hour. Water was applied to the shelter and weapons during the fire by the installation fire department. The fire melted the weapons grade plutonium (WGP) that was contained in the device. Turbulent local atmospheric conditions and the water applied during the fire contributed to scattering of WGP to the environment.

WGP is comprised primarily of ^{239}Pu, with lesser mass amounts of ^{238}Pu, ^{240}Pu, ^{241}Pu, and ^{242}Pu. For many nuclear weapons, individual WGP isotopic assay information exists (classified). However, for the warhead on the BOMARC missile and other nuclear weapons produced during the same time, specific assay information is not available (Taschner 1998). Table 1 provides an estimate of the isotopic composition of the BOMARC missile based on information from Los Alamos National Laboratory (Taschner 1998) and soil analyses performed in 1997 (Rademacher 1999).

Table 1. Isotopic Composition (by mass) of WGP in BOMARC Weapon Based on Los Alamos National Laboratory Estimates and Soil Analyses (Rademacher 1999).

Isotope	Mass Percent*	Radiological Half-life (y) **
Pu-238	0.0099	87.74
Pu-239	93.7	24,110
Pu-240	5.6	6,560
Pu-241	0.47	14.35
Pu-242	Negligible	376,000

* Fractions in 1958 ** Walker *et al* 1984

The relative isotopic composition of WGP constituents changes over time due to radioactive decay. Shortly after chemical separation during production, the most significant change is due to the radioactive decay of ^{241}Pu:

$$^{241}\mathrm{Pu} \rightarrow {}^{241}\mathrm{Am} + {}^{0}_{-1}\beta .$$

The daughter product, ^{241}Am, is an α-particle emitter with a radiological half-life of 432 y (Walker *et al* 1984). Table 2 lists the major radiation(s) emitted by the primary constituents of WGP. For ^{239}Pu and ^{240}Pu, only infrequent low-energy photons are emitted. Direct assessment of either of

these isotopes in samples can be accomplished through high-resolution γ-spectroscopy if sample activities are reasonable high. For low activity concentration samples, the most common assessment technique is through chemical dissolution, chemical separation, and α-radiation or mass spectroscopy. Because the α-particle energies of the ^{239}Pu and ^{240}Pu are very close, α-spectroscopy analysis is incapable of resolving the two isotopes. For radiation protection purposes, however, this does not present a problem because each isotope has the same activity to dose conversion factor (Eckerman 1999). The best estimate of the $^{239+240}Pu$ to ^{241}Am activity concentration ratio for the BOMARC WGP contaminated soils is 5.4 (Rademacher 1999).

Table 2. Major Radiation Emissions of Primary WGP Constituents (Scheien 1992).

Radionuclide	α-Particle Energies (MeV) & Frequency	β-Particle Energies (MeV) & Frequency	Photon Energies (MeV) & Frequency
Pu-239	5.155 (0.733) 5.143 (0.151) 5.105 (0.115)	None	0.113 (0.0005) 0.014 (0.044)
Pu-240	5.168 (0.735) 5.123 (0.264)	None	0.054 (0.0005) 0.014 (0.11)
Pu-241	None	0.021 (1.00)	None
Am-241	5.486 (0.852) 5.443 (0.128) 5.388 (0.014)	None	0.014 (0.427) 0.0595 (0.359) 0.026 (0.024)

3. Methodology

The survey consisted of in-situ measurements, soil sample collection, and laboratory analysis of soil samples. In-situ γ-measurements were made on soil along the NAES transportation route. Soil samples were taken from these same locations and sent for radioanalysis. Additional in-situ γ- and α-measurements were made on the paved portions of the NAES transportation route. The Air Force agreed to collect measurements and samples at an interval of every one-eight mile. Because an automobile was used for transportation between sampling locations and its odometer was used for sample location spacing, it was more practical to set increments at 0.1 miles. This increment exceeded the one-eight mile increment and provided for more sampling and measurements.

3.1 Transportation Route and Rail Transfer Area Survey

3.1.1 Number of Measurements

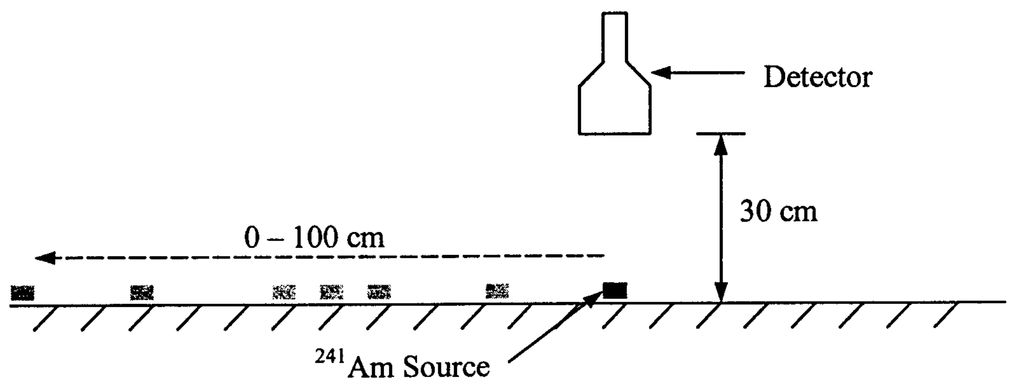
The Air Force agreed with the Navy to collect in-situ measurements at every soil sampling location. AFIERA/SDR decided to collect additional background in-situ measurements on asphalt and concrete road surfaces of the transportation route. This additional sampling was performed to assess background measurement conditions in the event contaminated soils were accidentally deposited on these surfaces. Mr. Martin, Navy RASO, and Capt Sheely, AFIERA. agreed that taking one measurement every other paved surfaces measurement location was sufficient to establish background conditions for the paved surfaces. A total of 94 measurement locations were set along the NAES transportation route. Among these, 31 locations had the additional in-situ measurement collected on an asphalt or concrete surface. At the railhead, it was decided to collect 27 soil samples and paired in-situ measurements. The approximate spacing for these measurements and sampling was 10 meters (m). Like the transportation route, additional in-situ measurements were collected on paved areas and the gravel base of the newly constructed rail spur. Figures A-1 and A-2 (Appendix A) contain sample and measurement locations.

3.1.2 In-Situ γ-Measurements

In-situ γ-measurements were performed using a Bicron 12.7 centimeter (cm) diameter x 1.6 millimeter (mm) thick thallium-drifted sodium iodide [NaI(Tl)] detector coupled with a Ludlum model 2221 scalar. The detector in this set-up is commonly referred to as a field instrument for the detection of low energy radiations (FIDLER). The model of detector used was fitted with a thin beryllium entrance window to minimize the attenuation of low energy photons. Prior to field survey work, at the AFIERA Instrument Calibration Facility (ICF), a relatively small energy window was set on the meter pulse height discriminator around the 59.5 keV ^{241}Am γ-ray along with instrument reliability checks. At the same time, measurements were collected with an ^{241}Am source at a distance of 30 cm from the detector entrance window at lateral distances from the perpendicular of 0, 20, 40, 50, 60, 80, and 100 cm as illustrated in Figure 1. These measurements were used to calculate surface detection efficiencies for use with the "Hot-Spot" computer code produced by Lawrence Livermore National Laboratory (LLNL). In the field, daily instrument reliability was assessed by collecting 15 sequential measurements with an ^{241}Am calibration source and the chi-square statistical test. Battery and discriminator checks were made daily. For these tests and field measurements, a

special detector stand was used to retain the detector at a constant detector to ground distance of 30 cm. Additional field measurements were collected with an ^{241}Am calibration source at lateral distances from the perpendicular of 0 and 50 cm. These field measurements were collected at a location near the railhead and described later in the report as the QA/QC location.

Figure 1. FIDLER Calibration Configuration.



3.1.3 α-Measurements

In-situ α-radiation measurements were made at the same locations as the in-situ γ-radiation measurements on the asphalt, concrete, and gravel surfaces. A Ludlum model 43-89 scintillator connected to a Ludlum model 2360 scalar was used for the measurements. Detector calibrations were conducted at the AFIERA ICF prior to the field survey work with a ^{239}Pu calibration source for the α-radiation channel, and ^{99}Tc and ^{90}Sr for the β-radiation channel. In the field, daily instrument battery checks were accomplished and α-radiation response was assessed with a thoriated lantern mantle.

3.2 Soil Sampling

3.2.1 Number of Samples

Soil samples were collected at the 94 measurement locations along the transportation route and at 27 locations around the railhead site. For the samples collected on the transportation route, sampling was conducted at the global positional system (GPS) measurement location. For samples at the rail transfer area, sample collection was split among gravel areas directly below the newly installed rail or at adjacent areas that contained soil. It was determined by discussions with AFIERA and the Navy representative that this approach provided more information about background radiological conditions rather than just the sampling of one media. For measurements along the rail transfer area, GPS measurements were uniformly collected only at soil areas, regardless of whether the sample was collected at the soil location or the gravel beneath the rail. The separation distance between the soil locations and gravel sampling/in-situ measurement locations was about 3 m.

3.2.2 Soil Samples

Soil samples were collected on the surface to a depth of approximately 0.5 cm. To ensure adequate sample mass for γ-spectroscopy analysis, a minimum required sample mass was set at 200 grams (g). Actual sample masses ranged from 275 to over 1212 g. Vegetation, large stones, etc. were rejected from collection in the field. Sampling location was annotated on the plastic sample bag containers in the field. Prior to preparation for packaging and shipment, the samples were enclosed in an additional plastic bag. A chain of custody form was enclosed with the samples prior to shipment. Field sampling tools were cleaned between sampling locations with de-ionized water. At every tenth sampling location, two duplicate samples were collected: one for Framatome ANP, Inc., a private commercial laboratory (also providing quality assurance analysis of soils for Duratek, Inc. during the remediation and final status survey phase of the BOMARC site remediation), and the other for Navy RASO.

3.2.3 Laboratory Analysis

In the laboratory, samples were weighed, dried in an oven at 44 °C for 24 hours, sieved to remove stones, blended, and homogenized. One gram (nominal) and 100 g aliquots were pulled from the preparations for α- and γ-spectroscopy analyses, respectively.

The Air Force and Navy agreed to isotopic plutonium analysis for the soils. AFIERA, based on routine procedure for unknown samples, also performed high-resolution γ-spectroscopy prior to the isotopic plutonium analysis procedure. Aliquots prepared for γ-spectroscopy analysis were placed in 250 ml right-cylindrical polyethylene containers and counted for 10,000 seconds (~ 2.8 hours). A peak search was accomplished with Canberra Inc. Genie 2000™ γ-spectroscopy software to identify isotopic content. The analytical results were reviewed for identified radiological constituents. Reported analytical results for ^{228}Ac, ^{241}Am, ^{137}Cs, ^{40}K, and ^{234}Th were compiled.

Aliquots prepared for α-spectroscopy analysis were mixed with a highly concentrated mixture of HF, HNO_3, and HCl, and heated to high temperature and pressure in a CEM Corp. microwave digestion system (if necessary for complete dissolution). A ^{242}Pu tracer was added to every aliquot to assess chemical recovery. Plutonium chemical separations were accomplished with BioRad™ resin. Plutonium was coprecipitated with a cerium fluoride carrier onto Tuffryn™ membrane filters [25 mm diameter, 0.2 μm pore size]. Passive implanted planer silicon detectors contained in vacuum chambers were used to count sample α-radiation emission by energy. Samples were counted for 20,000 seconds (~ 5.6 hours), with background counted for 86,400 seconds (24 hours). ^{242}Pu tracer recovery and $^{239+240}$Pu activity concentrations were assessed using Canberra Inc. Genie 2000™ α-spectroscopy software.

3.3 Global Positional System Measurements

The Environmental Division of Lakehurst NAES provided GPS measurements. The measurements were collected with a Trimble™ GPS Pathfinder Pro XR satellite positioning system (Trimble 1998). The Environmental Division used post-processing differential correction to achieve accuracy within 1 m. GPS location in New Jersey State Grid Coordinates was downloaded for this report.

3.4 Survey Personnel

Table 3 contains a listing of the survey personnel. Some personnel only participated in one part of the survey. For these individuals, the specific portion of survey participation in annotated.

Table 3. Survey Personnel.

Health Physicist	Steven Rademacher	AFIERA/SDR
Health Physicist	Lary Martin	NAVSEADET RASO
Health Physicist (January Only)	Eugene Sheely	AFIERA/SDRH
Health Physics Technician (January Only)	Donald Carbajal	AFIERA/SDRH
Health Physics Technician	Kimberly Murchison	AFIERA/SDRH
GIS Technician (January Survey Only)	John Crawford	Environmental Division, Lakehurst NAES
GIS Technician (April Survey Only)	Jessica Ditner	Environmental Division, Lakehurst NAES

4. Results and Discussion

4.1 In-Situ Measurement and Soil Sampling Locations

Figure A-1, Appendix A, provides a map of Lakehurst NAES with detailed annotation of the soil sampling and in-situ measurement locations from the January 2002 portion of the background survey. For the locations along the transportation route, sample identification (i.e., NAES001, NAES011, etc.) annotation was made for every tenth location. Locations are in sequential order, allowing interpolation for those locations without annotation. During the January 2002 survey, two rail transfer location samples (RH001 and RH002) were collected on grassy areas on the opposite side of the road from the rail spur. As well, the QA/QC location, where background and calibration measurements were made, was on the opposite side of the road, but farther down from the rail transfer area.

Figure A-2 provides a map with detail of the rail transfer area measurement and sampling locations from the April 2002 portion of the survey. This plot contains locations: RH001, RH002, and QA/QC that are also contained on Figure A-1. Sampling locations RH003 - RH027 are in sequential order, with annotations at every fifth location. Locations RH003 – RH025 encompassed the rail spur and had approximate spacing of 10 m between them. Locations RH026 and RH027 did not contain rail, but did have some gravel material along the roadside and greater spacing between locations.

Table B-1, Appendix B, contains the field assessment positional data. The listing has measurement location identifier, GPS collection information and the corresponding New Jersey State Grid Coordinates.

4.2 In-Situ Measurement Data Summary

Table B-2 contains the in-situ measurement data. For measurements along the transportation route, there is a FIDLER measurement for every sampling location and one at every other adjacent pavement location where asphalt or concrete existed. For every pavement FIDLER measurement, an α-radiation measurement was collected at the same location. Many locations along the route were not paved and subsequently the Table contains a "NA" notation where adjacent measurements were not collected. At the rail transfer area, for every location, the Table contains a listing of the soil, gravel, and road measurements. For the measurements, the FIDLER and α-radiation measurements were collected at the same location.

Table 4 contains the summary statistics for the field in-situ measurements of the transportation route, while Table 5 contains the summary statistics for the rail transfer area. For the transportation route FIDLER measurements, the mean of the pavement measurements was lower than that of the soil measurements. Both sets of FIDLER measurements had good agreement between the mean and median values, an indication of symmetrical data distributions. Both data sets had similar standard deviations: 358 and 290 counts. For the measurements on soil, the maximum measurement was 3908 counts, more than double the mean, and six standard deviations higher than the mean of the data set. This observation may have been the result of a non-flat counting geometry, but generally illustrative of the variability that can be encountered in field measurements with FIDLER instruments. For the α-radiation measurements, the data ranged from 2 to 27 counts. The variability

observed is likely attributed to variability in road materials and the influence of naturally occurring radon progeny. An interesting observation from the data is that there is not a direct correlation between the α-radiation and FIDLER measurement data; often the areas of highest α-radiation had relatively low FIDLER response and visa versa.

Table 4. Summary Statistics for In-Situ Measurement Data (Transportation Route)

Summary Statistics	Integrated Counts (1-minute)		
	FIDLER Measurements		Pavement α-Radiation Measurement
	Soil	Pavement	
Mean	1765	1495	10.4
Median	1709	1516	9
Standard Deviation	358	290	5.7
Maximum	3908	1962	27
Minimum	1266	1005	2
Observations	94	31	31

Table 5. Summary Statistics for In-Situ Measurement Data (Rail Transfer Area)

Summary Statistics	Integrated Counts (1-minute)					
	FIDLER Measurements			α-Radiation Measurements		
	Soil	Gravel	Road	Soil	Gravel	Road
Mean	1008	859	1273	1.4	1.1	2.0
Median	985	801	1286	1	1	2
Standard Deviation	87	148	109	1.4	1.1	1.2
Maximum	1204	1244	1378	5	4	4
Minimum	892	682	798	0	0	0
Observations	25	25	25	25	25	25

For the rail transfer area, the FIDLER measurements, the highest mean was observed in the road measurements, with the gravel areas being the lowest, and the mean for the soil measurements between. This observation is opposite of that for the transportation route. Among rail transfer area measurement data sets, the standard deviation of the soil data was lowest and the gravel highest. Overall, for the three FIDLER data sets, variability was lower than those on the transportation route. This observation is logical since the transportation route has greater variability in terrain and surface conditions than the rail transfer area. For the α-radiation measurements, overall among the three measurement areas the results were comparable and did not have as many high measurements as observed on the transportation route.

4.3 In-Situ Measurement Instrument Calibrations and Hot-Spot Calculations

Appendix C contains copies of the in-situ calibration documents for the calibrations completed at the AFIERA ICF. The logs for daily reliability tests conducted in the field at the QA/QC location are contained in Appendix C. The chi-square tests conducted indicated that the instruments passed. Table C contains the Hot-Spot calculations for the FIDLER used in the field. The "K" parameter was calculated using the AFIERA ICF calibration data. The parameters of mean background and instrument response to the ^{241}Am source at lateral distance of 0 cm was based on field measurements. These measurements and calculations should be periodically checked with FIDLER instrumentation to assess consistency in response.

The FIDLER instrument is susceptible to temperature fluctuations as are all field portable [NaI(Tl)] detection systems. The in-situ measurements for this background survey were conducted over field conditions that had a significant fluctuation in temperature. The first survey day, 9 Jan 02 was the coldest, with the FIDLER instrument having a mean background of 1804 counts at the QA/QC location. 10 Jan 02 was warmer and had a mean FIDLER background response of 1738 counts, a fairly minor difference. 9 Apr 02 had two sets of measurements: one in the morning when it was relatively cool and one at the end of the survey when it had warmed. The mean FIDLER background response for these sets of measurements was 1450 and 1224 counts, respectively, for the early and later data sets. For routine FIDLER survey work at the rail transfer area during transportation operations should have background and calibration measurements conducted at the same location to ensure consistency and allow for background corrections if necessary. The post transportation FIDLER measurements should use the same QA/QC measurement location as used in this survey.

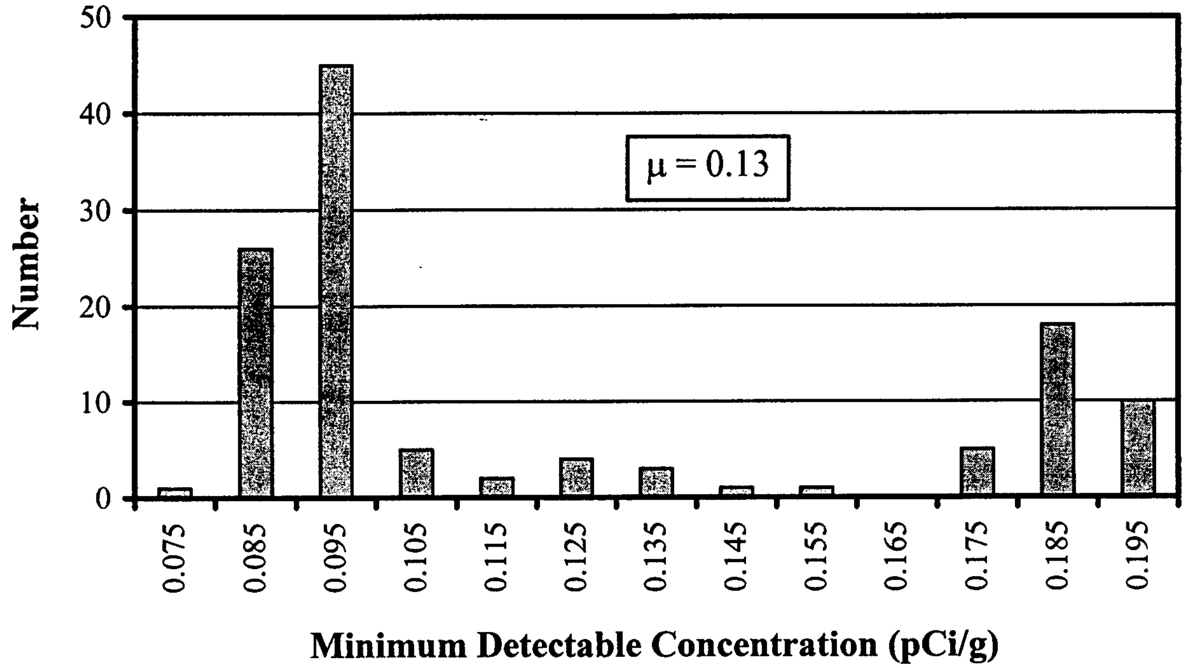
4.4 Laboratory γ-Spectroscopy Analysis Results

Table B-3 contains the AFIERA/SDRD analytical results for the γ-spectroscopy analysis. One hundred twenty-one samples were analyzed. The results were reviewed for identified radiological constituents. The review did not identify any isotopes besides those that are typical constituents of natural background and sources of worldwide fallout. To document representative concentrations of some typical constituents of background and fallout, data was compiled for ^{228}Ac, ^{137}Cs, ^{40}K, and ^{234}Th. ^{241}Am is a constituent of fallout, but normally isn't in concentrations that are traditionally detected by γ-spectroscopy analysis. However, since it is a co-contaminant in the BOMARC WGP, the minimum detectable concentrations (MDCs) are provided here for illustration of typical detection limits for this method.

For ^{228}Ac, 13 of the 121 samples had a reported concentration above the MDC, with the maximum at 0.62 ± 0.12 picocuries per gram (pCi g^{-1}). For the ^{137}Cs, 76 samples had a reported concentration above the MDC, with the maximum at 1.79 ± 0.17 pCi g^{-1}. For ^{40}K, 68 samples had a reported concentration above the MDC, with the maximum at 4.0 ± 1.0 pCi g^{-1}. For ^{234}Th, only 12 samples had a reported concentration above the MDC, with the maximum at 1.4 + 0.7 pCi g^{-1}. None of the samples had a reported ^{241}Am concentration above the MDC. Figure 2 is a histogram of the MDCs for the 121 samples. From the plot, there are a significant number of samples with an MDC at or below 0.1 pCi g^{-1}, but due to some samples with high MDC, the mean was 0.13 pCi g^{-1}. The highest

MDC was 0.2 pCi g^{-1}. For the BOMARC WGP and an estimated $^{239+240}Pu$ to ^{241}Am ratio, the surrogate $^{239+240}Pu$ MDC would be 1.1 pCi g^{-1}, in close proximity to the agreed remediation criterion of 1 pCi g^{-1} for Lakehurst NAES, in the event that there is an accidental release during transportation operations.

Figure 2. Histogram of ^{241}Am Minimum Detectable Concentrations.



4.5 Laboratory Isotopic Plutonium Analysis Results

Table B-4 contains the laboratory isotopic plutonium results. For these samples, the reported result is listed, with the MDC for the sample, and plutonium chemical recovery. In contrast to the γ-spectroscopy results, these results are reported in femtocuries per gram quantities because the concentrations were extremely low (1000 femtocuries is equal to one picocurie). Of the 121 analyses, only 17 had reported results greater than the MDC. The reported results ranged from (-7 + 8) to (80 ± 50) fCi g^{-1}, with a mean and median of 11.8 and 9 fCi g^{-1}, respectively.

The α-spectral plot from the sample at location NAES046 is provided in Figure 3. The dominant peak in the plot is from ^{242}Pu, the chemical tracer added to assess chemical recovery. The $^{239+240}Pu$ channel is higher in energy than the ^{242}Pu peak, as annotated on the plot, but has significantly lower activity. The summed net counts in the $^{239+240}Pu$ channel was 12.7 counts, thus explaining the relatively high level of uncertainty for extremely low activity concentration samples.

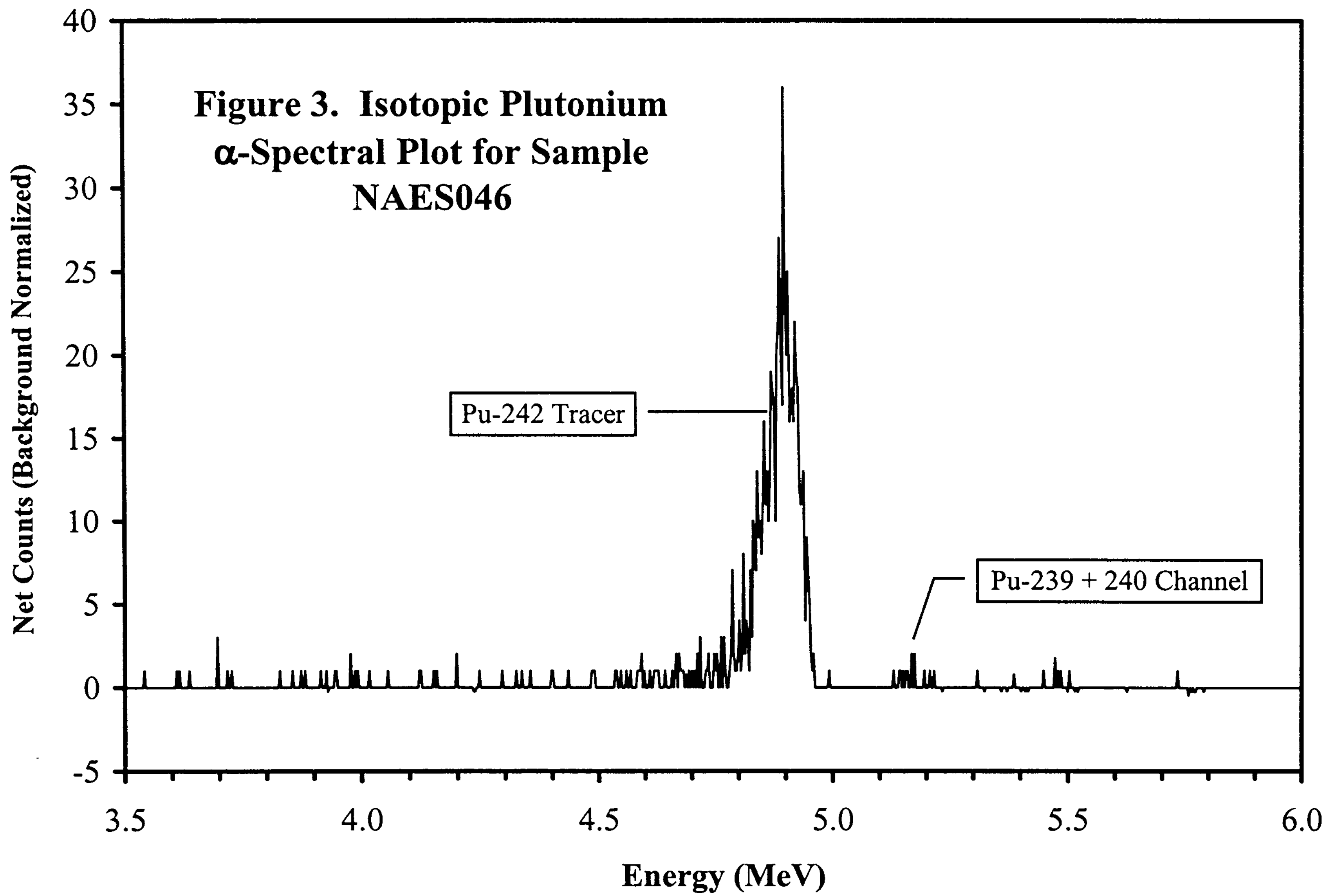
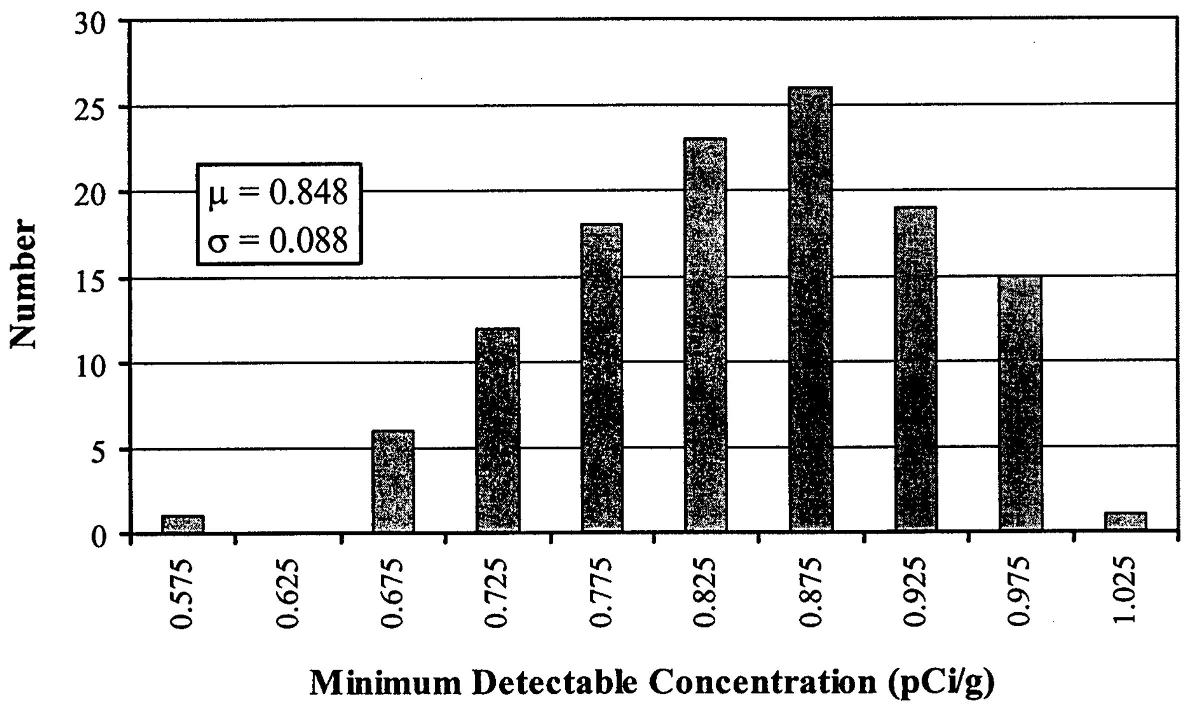


Figure 3. Isotopic Plutonium α-Spectral Plot for Sample NAES046

Among the 121 samples, the MDC's ranged from 8 to 90 fCi g^{-1}, with a mean and median of 34.4 and 35, respectively. Compared to the mean and maximum surrogate MDCs through use of ^{241}Am by γ-spectroscopy, this method is respectively, 20 and 15 times more sensitive. This method is more than adequate for measurements to meet the 1 pCi g^{-1} remediation criterion on Lakehurst NAES in the event of an accidental release.

Figure 4 contains a histogram of chemical recovery for the isotopic plutonium analyses. Overall, good chemical recoveries were observed. The recovery values ranged from 0.56 to 1.02, with a mean and standard deviation of 0.848 and 0.088, respectively.

Figure 4. Isotopic Plutonium Chemical Recovery Histogram.



For the 10 % AFIERA/SDRR duplicate samples, good agreement was observed in the paired analyses results. As well, for the 10 % duplicate samples sent to Framatome, good agreement was observed.

5. Conclusions

This report documents a radiological baseline survey conducted in support of the truck transport and rail transfer of WGP from the BOMARC site through Lakehurst NAES to rail facilities connecting to the NAES. The survey established pre-existing radiological conditions for both in-situ α-radiation and γ-radiation, and for $^{239+240}Pu$.

Portable instrument measurements were typical for uncontaminated areas, with some variability that should be accounted for in field survey work accomplished while supporting transportation operations and for the post-remediation survey to be accomplished after transportation has ceased. Detectable concentrations of $^{239+240}Pu$ were identified in the samples, with a mean and maximum concentrations of 11.8 and 80 fCi g^{-1}, respectively.

6. Acknowledgements

Special thanks to Lary Martin, Navy RASO, and the staff of the Environmental Division of Lakehurst, NAES for valuable support in this project.

Special thanks to the AFIERA/SDRR staff for rush analysis of the samples to support the transportation plan tight timelines.

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8. LIST OF ACRONYMS

Ac	actinium
AFB	Air Force Base
AFIERA	Air Force Institute for Environmental Safety, and Occupational Health Risk Analysis
Am	americium
BOMARC	Boeing Michigan Aeronautical Research Center
cm^2	centimeters squared
cpm	counts per minute
Cs	cesium
fCi	femtocurie
FIDLER	field instrument for the detection of low energy radiation
ICF	Instrument Calibration Facility
K	potassium
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
NA	not applicable
NAES	Naval Air and Engineering Station
NaI(Tl)	thallium-drifted sodium iodide
pCi	picocurie
Pu	plutonium
RASO	Radiological Affairs Support Office
SDR	Radiation Surveillance Division
SDRH	Health Physics Branch
Th	thorium

Appendix A

Lakehurst Overall Site and Rail Transfer Area

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Figure A-1. January 2002 Lakehurst Radiological Background Study

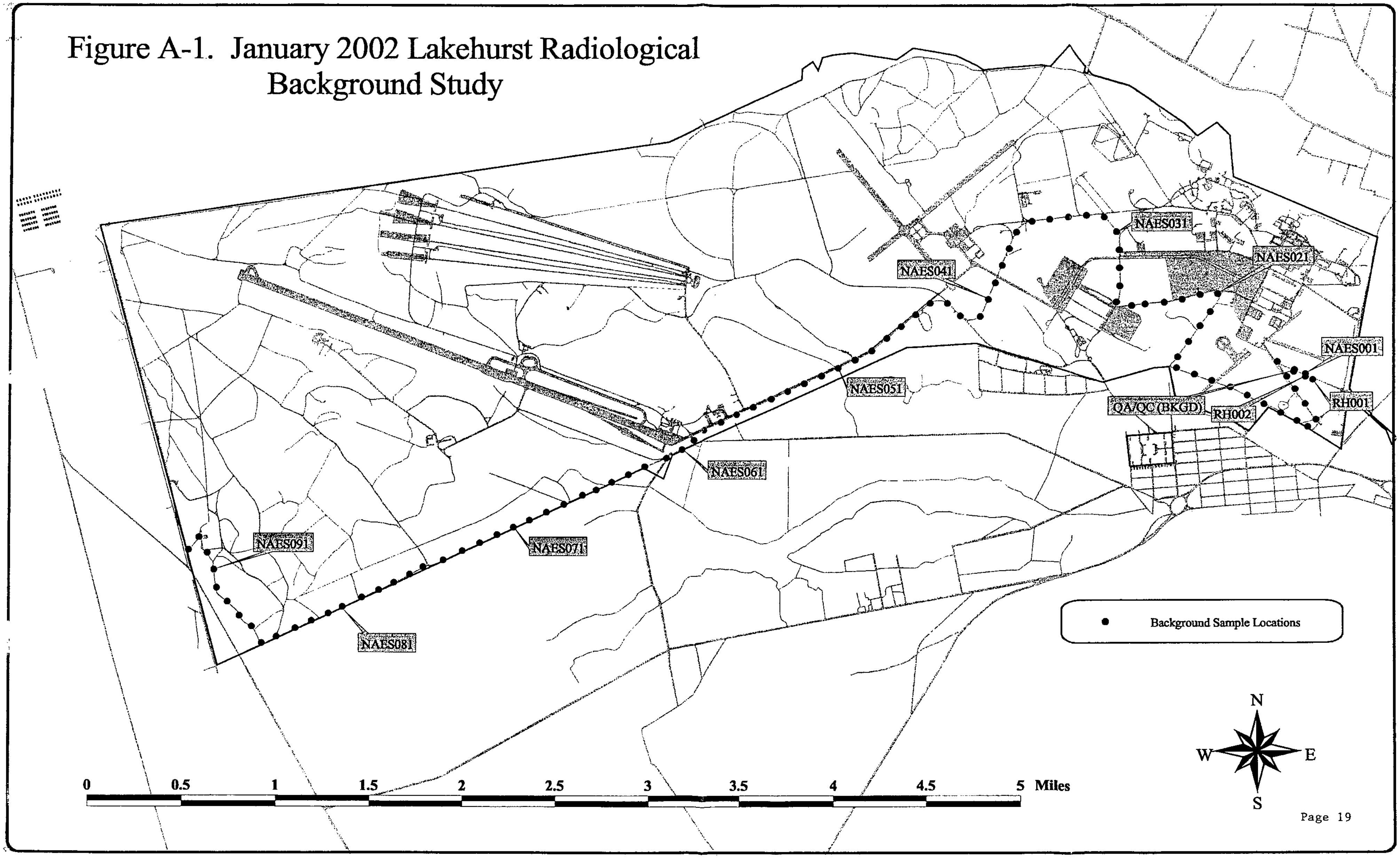
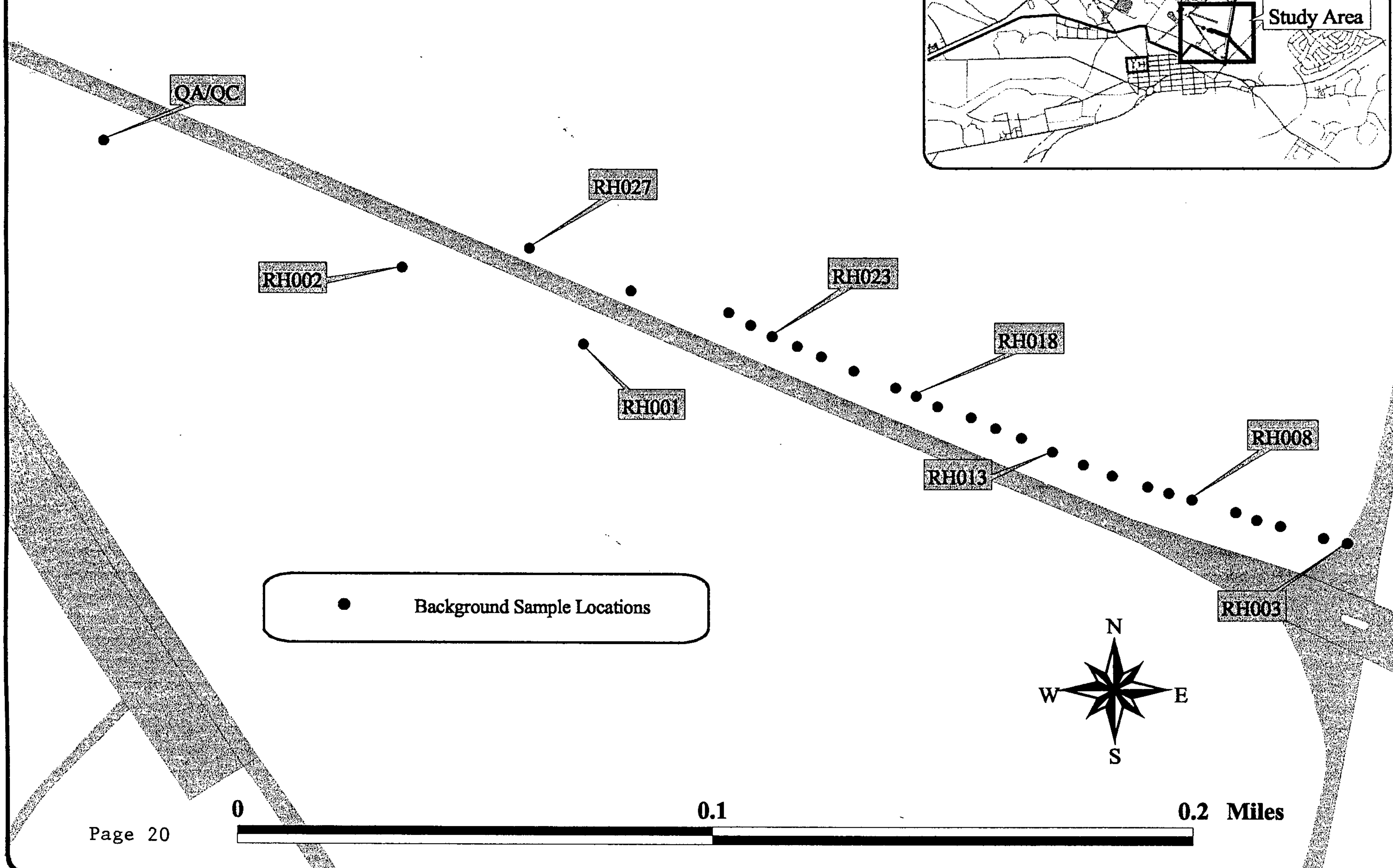


Figure A-2. January and April 2002 Lakehurst Radiological Background Study



Appendix B

Baseline Survey Results

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Table B-1. BOMARC Field Assessment Positional Data

Measurement Location Identifier	Maximum PDOP	Positional Correction Type	GPS Reveiver Type	GPS Collection Date	Positional Standard Deviation	Elevation Above MSL (feet)	New Jersey State Grid Coordinates	
							Latitude	Longitude
QA/QC	2.0	Differential	Pro XR	9-Jan-02	0.217147	70.4	544000.39050	433066.75300
RH001	2.8	Differential	Pro XR	9-Jan-02	0.298068	69.0	544531.89530	432842.37670
RH002	2.7	Differential	Pro XR	9-Jan-02	0.672914	72.1	544329.87320	432926.28700
NAES001	3.4	Differential	Pro XR	8-Jan-02	1.959445	70.2	544329.01970	433001.81120
NAES002	3.1	Differential	Pro XR	8-Jan-02	0.059551	71.7	544027.46130	433127.01450
NAES003	2.9	Differential	Pro XR	8-Jan-02	0.123147	72.7	543550.49780	433354.98210
NAES004	5.4	Differential	Pro XR	8-Jan-02	0.242941	71.3	543815.61120	432928.99930
NAES005	6.6	Differential	Pro XR	8-Jan-02	0.821663	67.2	544043.71410	432570.71150
NAES006	4.7	Differential	Pro XR	8-Jan-02	0.144862	66.8	544320.56040	432149.22160
NAES007	2.0	Differential	Pro XR	8-Jan-02	0.098085	67.8	544625.67830	431695.15430
NAES008	2.7	Differential	Pro XR	8-Jan-02	0.089626	63.4	544392.67300	431486.83990
NAES009	2.3	Differential	Pro XR	8-Jan-02	0.104213	66.0	544095.65770	431655.43450
NAES010	4.8	Differential	Pro XR	8-Jan-02	0.331690	71.9	543642.88720	431888.11760
NAES011	2.2	Differential	Pro XR	8-Jan-02	0.205083	77.6	543181.48970	432139.62270
NAES012	4.9	Differential	Pro XR	8-Jan-02	1.050083	69.2	542716.99040	432395.27700
NAES013	2.2	Differential	Pro XR	8-Jan-02	0.174734	67.4	542253.49540	432628.44990
NAES014	2.2	Differential	Pro XR	8-Jan-02	0.231405	70.9	541733.42260	432819.65680
NAES015	2.2	Differential	Pro XR	8-Jan-02	0.207858	77.8	541257.40900	432992.70130
NAES016	6.1	Differential	Pro XR	8-Jan-02	0.611370	50.1	540758.56350	433181.13740
NAES017	4.8	Differential	Pro XR	8-Jan-02	0.315812	67.7	540794.38710	433492.08660
NAES018	4.7	Differential	Pro XR	8-Jan-02	0.218504	72.3	541089.41290	433923.71540
NAES019	4.7	Differential	Pro XR	8-Jan-02	0.098761	79.9	541406.81290	434370.91400
NAES020	4.6	Differential	Pro XR	8-Jan-02	0.463387	90.6	541693.07600	434769.61780
NAES021	4.5	Differential	Pro XR	8-Jan-02	0.249792	75.9	541903.88960	435274.77040
NAES022	7.0	Differential	Pro XR	8-Jan-02	0.304238	76.9	541409.51910	435256.61110

Table B-1. BOMARC Field Assessment Positional Data

Measurement Location Identifier	Maximum PDOP	Positional Correction Type	GPS Reveiver Type	GPS Collection Date	Positional Standard Deviation	Elevation Above MSL (feet)	New Jersey State Grid Coordinates	
							Latitude	Longitude
NAES023	3.1	Differential	Pro XR	8-Jan-02	0.113300	73.7	540910.58730	435125.18860
NAES024	3.1	Differential	Pro XR	8-Jan-02	0.091612	75.2	540418.50960	435039.69220
NAES025	3.1	Differential	Pro XR	8-Jan-02	0.263503	72.6	539872.69260	434992.94420
NAES026	3.6	Differential	Pro XR	8-Jan-02	0.181170	74.7	539502.13150	434951.45980
NAES027	3.6	Differential	Pro XR	8-Jan-02	0.275182	79.1	539096.23220	435062.67140
NAES028	3.8	Differential	Pro XR	8-Jan-02	0.604030	76.2	539186.21650	435514.93330
NAES029	3.0	Differential	Pro XR	8-Jan-02	0.237093	75.1	539176.18660	436029.70540
NAES030	3.0	Differential	Pro XR	8-Jan-02	0.316161	83.3	539169.78370	436541.23120
NAES031	3.0	Differential	Pro XR	8-Jan-02	0.109355	84.7	539099.32250	437060.81600
NAES032	2.9	Differential	Pro XR	8-Jan-02	0.344142	80.5	538753.32130	437476.47280
NAES033	3.0	Differential	Pro XR	8-Jan-02	0.122257	74.2	538259.84010	437527.04000
NAES034	2.9	Differential	Pro XR	8-Jan-02	0.150532	71.6	537719.56700	437474.12860
NAES035	2.8	Differential	Pro XR	8-Jan-02	0.253252	77.6	537195.37820	437421.96800
NAES036	4.0	Differential	Pro XR	8-Jan-02	1.024771	92.6	536695.14000	437367.38930
NAES037	2.7	Differential	Pro XR	8-Jan-02	0.115574	88.7	536274.37260	437059.71720
NAES038	2.6	Differential	Pro XR	8-Jan-02	0.066249	82.9	536080.22630	436584.49760
NAES039	2.6	Differential	Pro XR	8-Jan-02	0.413644	81.2	535880.05370	436100.77560
NAES040	2.5	Differential	Pro XR	8-Jan-02	0.137640	82.9	535684.81230	435605.70650
NAES041	2.5	Differential	Pro XR	8-Jan-02	0.408373	76.7	535490.67500	435131.98870
NAES042	2.8	Differential	Pro XR	8-Jan-02	0.085098	83.6	535260.99560	434654.68270
NAES043	2.8	Differential	Pro XR	8-Jan-02	0.139155	79.3	534699.58070	434669.65060
NAES044	2.7	Differential	Pro XR	8-Jan-02	0.181712	72.7	534338.73700	435017.19560
NAES045	2.7	Differential	Pro XR	8-Jan-02	0.237699	79.2	533849.34910	435026.92730
NAES046	2.7	Differential	Pro XR	8-Jan-02	0.215336	84.8	533434.94980	434696.87640
NAES047	2.7	Differential	Pro XR	8-Jan-02	0.310199	80.8	533029.59960	434362.15290

Table B-1. BOMARC Field Assessment Positional Data

Measurement Location Identifier	Maximum PDOP	Positional Correction Type	GPS Reveiver Type	GPS Collection Date	Positional Standard Deviation	Elevation Above MSL (feet)	New Jersey State Grid Coordinates	
							Latitude	Longitude
NAES048	3.2	Differential	Pro XR	8-Jan-02	0.279655	74.5	532627.02440	434030.16110
NAES049	3.3	Differential	Pro XR	8-Jan-02	0.095398	83.1	532199.83660	433672.47830
NAES050	3.9	Differential	Pro XR	9-Jan-02	0.072296	80.9	531725.16150	433413.12740
NAES051	3.9	Differential	Pro XR	9-Jan-02	0.356958	85.4	531243.15210	433184.45880
NAES052	3.9	Differential	Pro XR	9-Jan-02	0.086588	76.8	530772.90100	432966.45720
NAES053	3.8	Differential	Pro XR	9-Jan-02	0.397199	80.6	530291.49360	432743.35490
NAES054	3.5	Differential	Pro XR	9-Jan-02	0.242468	81.5	529819.74180	432520.46410
NAES055	3.5	Differential	Pro XR	9-Jan-02	0.576269	85.6	529343.81930	432302.07740
NAES056	3.4	Differential	Pro XR	9-Jan-02	0.220797	83.4	528849.34590	432070.93160
NAES057	3.1	Differential	Pro XR	9-Jan-02	0.308921	87.3	528386.05490	431855.83070
NAES058	3.0	Differential	Pro XR	9-Jan-02	0.219139	90.4	527927.80890	431631.33920
NAES059	2.8	Differential	Pro XR	9-Jan-02	0.225763	88.1	527444.00910	431403.56500
NAES060	2.7	Differential	Pro XR	9-Jan-02	0.074766	93.4	527123.79430	431117.83030
NAES061	2.6	Differential	Pro XR	9-Jan-02	0.155350	91.9	526778.69840	430851.31430
NAES062	2.5	Differential	Pro XR	9-Jan-02	0.244033	93.4	526326.04790	430610.94350
NAES063	2.1	Differential	Pro XR	9-Jan-02	0.270338	97.3	525718.37020	430366.08610
NAES064	3.3	Differential	Pro XR	9-Jan-02	0.463817	105.0	525249.88660	430134.26740
NAES065	3.4	Differential	Pro XR	9-Jan-02	0.215743	84.5	524772.26440	429917.71850
NAES066	3.6	Differential	Pro XR	9-Jan-02	0.871048	95.1	524328.90160	429691.04750
NAES067	6.0	Differential	Pro XR	9-Jan-02	0.462114	98.1	523945.30770	429536.27030
NAES068	2.2	Differential	Pro XR	9-Jan-02	0.324723	102.1	523419.28300	429282.25760
NAES069	3.1	Differential	Pro XR	9-Jan-02	0.080513	95.2	522922.26400	429054.79330
NAES070	7.0	Differential	Pro XR	9-Jan-02	0.462707	102.1	522429.84780	428825.45080
NAES071	3.3	Differential	Pro XR	9-Jan-02	0.363548	98.6	521976.05360	428615.14880
NAES072	3.6	Differential	Pro XR	9-Jan-02	0.601645	117.0	521512.47450	428405.49530

Table B-1. BOMARC Field Assessment Positional Data

Measurement Location Identifier	Maximum PDOP	Positional Correction Type	GPS Reveiver Type	GPS Collection Date	Positional Standard Deviation	Elevation Above MSL (feet)	New Jersey State Grid Coordinates	
							Latitude	Longitude
NAES073	7.1	Differential	Pro XR	9-Jan-02	0.983762	99.8	521024.01800	428167.76940
NAES074	6.9	Differential	Pro XR	9-Jan-02	0.987559	95.5	520534.50530	427940.56580
NAES075	4.1	Differential	Pro XR	9-Jan-02	0.127332	107.1	519996.59670	427678.83700
NAES076	4.0	Differential	Pro XR	9-Jan-02	0.297707	108.3	519429.10340	427483.21790
NAES077	4.5	Differential	Pro XR	9-Jan-02	0.291575	110.5	519038.09860	427277.62610
NAES078	3.9	Differential	Pro XR	9-Jan-02	0.624931	115.6	518590.19130	427040.86380
NAES079	3.8	Differential	Pro XR	9-Jan-02	0.480009	112.3	518159.60060	426822.28250
NAES080	3.6	Differential	Pro XR	9-Jan-02	0.214749	112.5	517691.62900	426615.43990
NAES081	3.3	Differential	Pro XR	9-Jan-02	0.591396	117.8	517144.17290	426345.87540
NAES082	2.4	Differential	Pro XR	9-Jan-02	0.255637	123.3	516741.15880	426153.58690
NAES083	4.4	Differential	Pro XR	9-Jan-02	0.258766	121.5	516268.09680	425943.62040
NAES084	6.9	Differential	Pro XR	9-Jan-02	0.798035	142.0	515811.48550	425735.00240
NAES085	3.1	Differential	Pro XR	9-Jan-02	0.154342	133.1	515287.80230	425488.78470
NAES086	4.9	Differential	Pro XR	9-Jan-02	0.670256	140.1	514867.87700	425308.22280
NAES087	5.1	Differential	Pro XR	9-Jan-02	0.595648	157.3	514588.36980	425779.15400
NAES088	5.4	Differential	Pro XR	9-Jan-02	0.502648	183.3	514250.14130	426092.08450
NAES089	5.2	Differential	Pro XR	9-Jan-02	0.472848	178.8	513905.94000	426491.50710
NAES090	4.9	Differential	Pro XR	9-Jan-02	0.553378	179.7	513602.06890	426891.79630
NAES091	6.8	Differential	Pro XR	9-Jan-02	0.507429	176.5	513519.98390	427403.15110
NAES092	7.6	Differential	Pro XR	9-Jan-02	0.997502	181.5	513334.20810	427887.00640
NAES093	2.6	Differential	Pro XR	9-Jan-02	0.321068	175.6	513096.34970	428333.15290
NAES094	6.6	Differential	Pro XR	9-Jan-02	1.239629	184.8	512802.72640	427971.71100

Table B-1. BOMARC Field Assessment Positional Data

Measurement Location Identifier	Maximum PDOP	Positional Correction Type	GPS Reveiver Type	GPS Collection Date	Positional Standard Deviation	Elevation Above MSL (feet)	New Jersey State Grid Coordinates	
							Latitude	Longitude
RH003	4.6	Differential	Pro XR	9-Apr-02	1.347652	67.07	545370.8214	432619.4515
RH004	4.8	Differential	Pro XR	9-Apr-02	0.255349	76.45	545345.1758	432625.1261
RH005	5.1	Differential	Pro XR	9-Apr-02	0.215781	73.16	545298.9131	432638.4082
RH006	5.3	Differential	Pro XR	9-Apr-02	0.258088	81.67	545272.9103	432645.2623
RH007	5.4	Differential	Pro XR	9-Apr-02	0.169480	69.53	545250.4456	432654.0967
RH008	3.4	Differential	Pro XR	9-Apr-02	0.053118	71.52	545203.0737	432668.1501
RH009	5.8	Differential	Pro XR	9-Apr-02	0.116163	68.74	545177.8281	432675.5061
RH010	5.9	Differential	Pro XR	9-Apr-02	0.170395	72.01	545154.4902	432682.3874
RH011	6.2	Differential	Pro XR	9-Apr-02	0.304184	73.34	545115.7623	432694.843
RH012	6.3	Differential	Pro XR	9-Apr-02	0.136344	67.11	545083.9817	432707.4143
RH013	6.7	Differential	Pro XR	9-Apr-02	0.087434	69.56	545050.7561	432721.9165
RH014	2.9	Differential	Pro XR	9-Apr-02	0.180344	68.57	545016.8992	432737.0143
RH015	2.9	Differential	Pro XR	9-Apr-02	0.170396	69.73	544988.9748	432747.9719
RH016	2.3	Differential	Pro XR	9-Apr-02	0.174758	70.51	544962.0859	432760.416
RH017	2.3	Differential	Pro XR	9-Apr-02	0.249294	72.06	544924.7062	432772.762
RH018	3.5	Differential	Pro XR	9-Apr-02	0.197062	70.63	544901.0385	432784.5636
RH019	2.3	Differential	Pro XR	9-Apr-02	0.070284	69.26	544878.2419	432793.8894
RH020	2.3	Differential	Pro XR	9-Apr-02	0.088574	69.59	544832.2501	432812.8255
RH021	3.4	Differential	Pro XR	9-Apr-02	0.087929	68.9	544796.1584	432828.7955
RH022	2.9	Differential	Pro XR	9-Apr-02	0.176876	68.81	544769.472	432840.5083
RH023	3.4	Differential	Pro XR	9-Apr-02	0.262055	71.15	544741.7883	432851.2283
RH024	3.3	Differential	Pro XR	9-Apr-02	0.211449	69.92	544717.7694	432863.6257
RH025	2.3	Differential	Pro XR	9-Apr-02	0.184058	68.45	544693.8583	432877.3912
RH026	2.3	Differential	Pro XR	9-Apr-02	0.071464	69.6	544584.9156	432901.4082
RH027	2.3	Differential	Pro XR	9-Apr-02	0.056418	70.53	544471.2942	432948.1117

Table B-2. BOMARC In-Situ Field Measurement Data

Measurement Location Identifier	FIDLER Measurement Data (1-minute Integrated Counts)				Adjacent Pavement Location 1-Minute Alpha Measurement
	GPS Measurement Location		Adjacent Pavement Location		
	Counts	Date	Counts	Date	
QA/QC	Every Measurement Day (Summarized in Other Tables)				NA
RH001	NC	09-Jan-02	NA	10-Jan-02	NA
RH002	NC	09-Jan-02	NA	10-Jan-02	NA
NAES001	1793	09-Jan-02	NA	10-Jan-02	NA
NAES002	1662	09-Jan-02	1833	10-Jan-02	10
NAES003	3908	09-Jan-02	NA	10-Jan-02	NA
NAES004	2809	09-Jan-02	1395	10-Jan-02	8
NAES005	2191	09-Jan-02	NA	10-Jan-02	NA
NAES006	2013	09-Jan-02	NA	10-Jan-02	NA
NAES007	1539	09-Jan-02	NA	10-Jan-02	NA
NAES008	1488	09-Jan-02	NA	10-Jan-02	NA
NAES009	1389	09-Jan-02	NA	10-Jan-02	NA
NAES010	1499	09-Jan-02	NA	10-Jan-02	NA
NAES011	1482	09-Jan-02	NA	10-Jan-02	NA
NAES012	1489	09-Jan-02	NA	10-Jan-02	NA
NAES013	1291	09-Jan-02	NA	10-Jan-02	NA
NAES014	1468	09-Jan-02	NA	10-Jan-02	NA
NAES015	1314	09-Jan-02	NA	10-Jan-02	NA
NAES016	1747	09-Jan-02	NA	10-Jan-02	NA
NAES017	1513	09-Jan-02	NA	10-Jan-02	NA
NAES018	1502	09-Jan-02	NA	10-Jan-02	NA
NAES019	1382	09-Jan-02	NA	10-Jan-02	NA
NAES020	1519	09-Jan-02	NA	10-Jan-02	NA
NAES021	1613	09-Jan-02	NA	10-Jan-02	NA
NAES022	1732	09-Jan-02	1868	10-Jan-02	10

Table B-2. BOMARC In-Situ Field Measurement Data

Measurement Location Identifier	FIDLER Measurement Data (1-minute Integrated Counts)				Adjacent Pavement Location 1-Minute Alpha Measurement
	GPS Measurement Location		Adjacent Pavement Location		
	Counts	Date	Counts	Date	
NAES023	1858	09-Jan-02	NA	10-Jan-02	NA
NAES024	1835	09-Jan-02	1962	10-Jan-02	9
NAES025	1775	09-Jan-02	NA	10-Jan-02	NA
NAES026	1731	09-Jan-02	1702	10-Jan-02	9
NAES027	1616	09-Jan-02	NA	10-Jan-02	NA
NAES028	1896	09-Jan-02	1536	10-Jan-02	11
NAES029	1943	09-Jan-02	NA	10-Jan-02	NA
NAES030	1521	09-Jan-02	1458	10-Jan-02	9
NAES031	2231	09-Jan-02	NA	10-Jan-02	NA
NAES032	1792	09-Jan-02	1756	10-Jan-02	5
NAES033	2011	09-Jan-02	NA	10-Jan-02	NA
NAES034	1942	09-Jan-02	1554	10-Jan-02	5
NAES035	1972	09-Jan-02	NA	10-Jan-02	NA
NAES036	2061	09-Jan-02	1758	10-Jan-02	11
NAES037	2279	09-Jan-02	NA	10-Jan-02	NA
NAES038	2106	09-Jan-02	1749	10-Jan-02	12
NAES039	1663	09-Jan-02	NA	10-Jan-02	NA
NAES040	2181	09-Jan-02	1541	10-Jan-02	9
NAES041	1786	09-Jan-02	NA	10-Jan-02	NA
NAES042	1634	09-Jan-02	1494	10-Jan-02	16
NAES043	1814	09-Jan-02	NA	10-Jan-02	NA
NAES044	1769	09-Jan-02	1493	10-Jan-02	5
NAES045	1702	09-Jan-02	NA	10-Jan-02	NA
NAES046	1464	09-Jan-02	1022	10-Jan-02	15
NAES047	1402	09-Jan-02	NA	10-Jan-02	NA

Table B-2. BOMARC In-Situ Field Measurement Data

Measurement Location Identifier	FIDLER Measurement Data (1-minute Integrated Counts)				Adjacent Pavement Location 1-Minute Alpha Measurement
	GPS Measurement Location		Adjacent Pavement Location		
	Counts	Date	Counts	Date	
NAES048	1378	09-Jan-02	1005	10-Jan-02	19
NAES049	1456	09-Jan-02	NA	10-Jan-02	NA
NAES050	1989	09-Jan-02	1078	10-Jan-02	27
NAES051	1923	09-Jan-02	NA	10-Jan-02	NA
NAES052	1920	09-Jan-02	1017	10-Jan-02	16
NAES053	1553	09-Jan-02	NA	10-Jan-02	NA
NAES054	1648	09-Jan-02	1053	10-Jan-02	16
NAES055	1715	09-Jan-02	NA	10-Jan-02	NA
NAES056	1626	09-Jan-02	1126	10-Jan-02	20
NAES057	1635	09-Jan-02	NA	10-Jan-02	NA
NAES058	1715	09-Jan-02	1076	10-Jan-02	16
NAES059	1676	09-Jan-02	NA	10-Jan-02	NA
NAES060	1560	09-Jan-02	1800	10-Jan-02	9
NAES061	1801	09-Jan-02	NA	10-Jan-02	NA
NAES062	1376	09-Jan-02	1491	10-Jan-02	14
NAES063	2014	09-Jan-02	NA	10-Jan-02	NA
NAES064	1833	09-Jan-02	1371	10-Jan-02	11
NAES065	1611	09-Jan-02	NA	10-Jan-02	NA
NAES066	1685	09-Jan-02	1305	10-Jan-02	4
NAES067	1532	09-Jan-02	NA	10-Jan-02	NA
NAES068	1641	09-Jan-02	1608	10-Jan-02	2
NAES069	1762	09-Jan-02	NA	10-Jan-02	NA
NAES070	2399	09-Jan-02	1675	10-Jan-02	4
NAES071	1890	09-Jan-02	NA	10-Jan-02	NA
NAES072	2063	09-Jan-02	1798	10-Jan-02	4

Table B-2. BOMARC In-Situ Field Measurement Data

Measurement Location Identifier	FIDLER Measurement Data (1-minute Integrated Counts)				Adjacent Pavement Location 1-Minute Alpha Measurement
	GPS Measurement Location		Adjacent Pavement Location		
	Counts	Date	Counts	Date	
NAES073	2446	09-Jan-02	NA	10-Jan-02	NA
NAES074	1950	09-Jan-02	1855	10-Jan-02	5
NAES075	1673	09-Jan-02	NA	10-Jan-02	NA
NAES076	1532	09-Jan-02	1441	10-Jan-02	6
NAES077	1592	09-Jan-02	NA	10-Jan-02	NA
NAES078	1810	09-Jan-02	1516	10-Jan-02	6
NAES079	1772	09-Jan-02	NA	10-Jan-02	NA
NAES080	1617	09-Jan-02	NA	10-Jan-02	NA
NAES081	1495	09-Jan-02	NA	10-Jan-02	NA
NAES082	1465	09-Jan-02	NA	10-Jan-02	NA
NAES083	1445	09-Jan-02	NA	10-Jan-02	NA
NAES084	1726	09-Jan-02	NA	10-Jan-02	NA
NAES085	1407	09-Jan-02	NA	10-Jan-02	NA
NAES086	1479	09-Jan-02	NA	10-Jan-02	NA
NAES087	1266	09-Jan-02	NA	10-Jan-02	NA
NAES088	1568	09-Jan-02	NA	10-Jan-02	NA
NAES089	1619	09-Jan-02	NA	10-Jan-02	NA
NAES090	2065	09-Jan-02	NA	10-Jan-02	NA
NAES091	1949	09-Jan-02	NA	10-Jan-02	NA
NAES092	2182	09-Jan-02	NA	10-Jan-02	NA
NAES093	1891	09-Jan-02	NA	10-Jan-02	NA
NAES094	2186	09-Jan-02	NA	10-Jan-02	NA

Table B-2. BOMARC In-Situ Field Measurement Data

Measurement Location Identifier	In-Situ Measurement Data (1-minute Integrated Counts)						
	Measurement Date	FIDLER Measurements			Alpha Measurement		
		Soil*	Gravel	Road	Soil*	Gravel	Road
RH003	9-Apr-02	1095	788	1317	1	0	3
RH004	9-Apr-02	1074	682	1352	0	0	4
RH005	9-Apr-02	1099	768	1264	1	0	2
RH006	9-Apr-02	1062	788	798	0	2	1
RH007	9-Apr-02	978	1082	1303	0	3	3
RH008	9-Apr-02	978	734	1348	0	2	1
RH009	9-Apr-02	1020	709	1378	1	1	4
RH010	9-Apr-02	1126	812	1283	0	1	3
RH011	9-Apr-02	1042	836	1286	0	0	2
RH012	9-Apr-02	942	941	1342	3	1	2
RH013	9-Apr-02	985	800	1293	1	1	2
RH014	9-Apr-02	892	877	1336	1	0	1
RH015	9-Apr-02	898	710	1299	2	0	0
RH016	9-Apr-02	914	789	1303	3	2	1
RH017	9-Apr-02	911	883	1219	0	2	1
RH018	9-Apr-02	926	793	1218	3	0	0
RH019	9-Apr-02	959	753	1253	1	1	3
RH020	9-Apr-02	930	883	1360	3	2	4
RH021	9-Apr-02	976	801	1270	2	1	3
RH022	9-Apr-02	994	884	1245	5	1	3
RH023	9-Apr-02	985	748	1256	2	1	0
RH024	9-Apr-02	996	887	1271	0	0	1
RH025	9-Apr-02	1013	1244	1342	2	4	2
RH026	9-Apr-02	1199	1223	1253	3	3	3
RH027	9-Apr-02	1204	1050	1245	2	0	2

*GPS Measurement at Soil Location, Gravel Measurement Locations between Rail and Road, Road Measurements in Center of Road

To Obtain α-Radiation Activity Concentration (dpm/100 cm^2) Multiply Count Rate by 3.78

Table B-3. BOMARC Soil Sample γ-Spectroscopy Analysis

Measurement Location Identifier	Soil Collection Date	Sample Identification		Gamma Spectroscopy Analytical Results Activity Concentration (pCi/g-dried)				
		Base	AFIERA SDRR	Ac-228	Am-241	Cs-137	K-40	Th-234
QA/QC	NA	NA	NA	NA	NA	NA	NA	NA
RH001	8-Jan-02	GS0202393	10100122	< 0.40	< 0.15	1.05 ± 0.12	0.8 ± 0.5	< 1.4
RH002	8-Jan-02	GS0202394	10100123	< 0.30	< 0.12	1.79 ± 0.17	< 1.0	< 1.2
NAES001	8-Jan-02	GS0202299	10100028	< 0.43	< 0.10	< 0.12	1.8 ± 0.6	< 1.2
NAES002	8-Jan-02	GS0202300	10100029	< 0.39	< 0.10	< 0.11	1.3 ± 0.6	< 1.1
NAES003	8-Jan-02	GS0202301	10100030	< 0.43	< 0.09	0.65 ± 0.10	2.0 ± 0.7	< 1.1
NAES004	8-Jan-02	GS0202302	10100031	< 0.35	< 0.11	1.7 ± 0.2	3.5 ± 0.8	0.7 ± 0.5
NAES005	8-Jan-02	GS0202303	10100032	< 0.35	< 0.10	1.4 ± 0.2	3.9 ± 0.9	0.8 ± 0.6
NAES006	8-Jan-02	GS0202304	10100033	< 0.38	< 0.09	0.83 ± 0.11	< 1.4	0.8 ± 0.6
NAES007	8-Jan-02	GS0202305	10100034	< 0.41	< 0.10	0.06 ± 0.05	< 1.3	< 1.1
NAES008	8-Jan-02	GS0202306	10100035	< 0.40	< 0.10	0.46 ± 0.08	1.7 ± 0.6	1.3 ± 0.6
NAES009	8-Jan-02	GS0202307	10100036	< 0.33	< 0.10	0.29 ± 0.07	0.8 ± 0.5	< 1.1
NAES010	8-Jan-02	GS0202308	10100037	< 0.44	< 0.10	< 0.11	1.7 ± 0.7	0.7 ± 0.6
NAES011	8-Jan-02	GS0202309	10100038	0.59 ± 0.14	< 0.10	0.09 ± 0.05	1.2 ± 0.6	< 1.1
NAES012	8-Jan-02	GS0202310	10100039	< 0.49	< 0.19	< 0.15	< 1.3	1.4 ± 0.7
NAES013	8-Jan-02	GS0202311	10100040	< 0.37	< 0.10	1.8 ± 0.5	< 1.1	< 1.1
NAES014	8-Jan-02	GS0202312	10100041	< 0.32	< 0.09	1.3 ± 0.04	< 0.97	< 0.91
NAES015	8-Jan-02	GS0202313	10100042	< 0.32	< 0.09	0.25 ± 0.06	< 1.1	0.7 ± 0.5
NAES016	8-Jan-02	GS0202314	10100043	< 0.36	< 0.10	0.24 ± 0.06	1.2 ± 0.5	< 1.1
NAES017	8-Jan-02	GS0202315	10100044	0.62 ± 0.12	< 0.11	< 0.07	1.6 ± 0.5	< 1.2
NAES018	9-Jan-02	GS0202316	10100045	< 0.35	< 0.10	0.56 ± 0.04	< 1.0	0.8 ± 0.5
NAES019	8-Jan-02	GS0202317	10100046	< 0.31	< 0.10	< 0.05	< 1.0	1.0 ± 0.5
NAES020	8-Jan-02	GS0202318	10100047	0.42 ± 0.09	< 0.10	0.05 ± 0.04	< 1.0	< 0.96
NAES021	8-Jan-02	GS0202319	10100048	< 0.31	< 0.09	< 0.09	< 0.93	< 1.1
NAES022	8-Jan-02	GS0202320	10100049	0.18 ± 0.10	< 0.09	0.12 ± 0.04	0.9 ± 0.4	< 1.0

Table B-3. BOMARC Soil Sample γ-Spectroscopy Analysis

Measurement Location Identifier	Soil Collection Date	Sample Identification		Gamma Spectroscopy Analytical Results Activity Concentration (pCi/g-dried)				
		Base	AFIERA SDRR	Ac-228	Am-241	Cs-137	K-40	Th-234
NAES023	8-Jan-02	GS0202321	10100050	< 0.36	< 0.10	1.1 ± 0.5	2.0 ± 0.5	0.9 ± 0.5
NAES024	8-Jan-02	GS0202322	10100051	< 0.44	< 0.18	< 0.13	1.4 ± 0.6	< 1.5
NAES025	8-Jan-02	GS0202323	10100052	< 0.29	< 0.09	0.24 ± 0.05	1.2 ± 0.5	< 1.0
NAES026	8-Jan-02	GS0202324	10100053	< 0.30	< 0.10	< 0.08	< 1.1	< 1.0
NAES027	8-Jan-02	GS0202325	10100054	< 0.33	< 0.09	0.15 ± 0.05	1.3 ± 0.5	< 1.0
NAES028	8-Jan-02	GS0202326	10100055	< 0.31	< 0.09	0.05 ± 0.04	1.2 ± 0.4	< 1.0
NAES029	8-Jan-02	GS0202327	10100056	< 0.35	< 0.10	0.05 ± 0.04	0.9 ± 0.4	< 1.1
NAES030	8-Jan-02	GS0202328	10100057	< 0.31	< 0.09	0.32 ± 0.06	1.6 ± 0.5	< 1.0
NAES031	8-Jan-02	GS0202329	10100058	0.48 ± 0.12	< 0.11	0.82 ± 0.10	1.4 ± 0.05	1.3 ± 0.6
NAES032	9-Jan-02	GS0202330	10100059	< 0.33	< 0.09	0.22 ± 0.06	< 0.96	< 1.1
NAES033	9-Jan-02	GS0202331	10100060	< 0.34	< 0.10	0.29 ± 0.06	< 1.1	< 1.1
NAES034	9-Jan-02	GS0202332	10100061	< 0.30	< 0.09	0.09 ± 0.04	1.1 ± 0.5	< 0.98
NAES035	9-Jan-02	GS0202333	10100062	< 0.30	< 0.09	0.09 ± 0.05	1.2 ± 0.4	< 1.0
NAES036	9-Jan-02	GS0202334	10100063	< 0.47	< 0.19	0.13 ± 0.07	0.7 ± 0.6	< 1.9
NAES037	9-Jan-02	GS0202335	10100064	< 0.39	< 0.09	< 0.12	0.7 ± 0.5	< 1.2
NAES038	10-Jan-02	GS0202336	10100065	< 0.45	< 0.10	0.28 ± 0.07	2.0 ± 0.7	< 1.3
NAES039	9-Jan-02	GS0202337	10100066	< 0.41	< 0.10	0.16 ± 0.06	< 1.4	< 1.3
NAES040	9-Jan-02	GS0202338	10100067	< 0.4	< 0.10	0.34 ± 0.07	1.0 ± 0.6	< 1.3
NAES041	9-Jan-02	GS0202339	10100068	0.59 ± 0.14	< 0.10	< 0.12	< 1.5	< 1.3
NAES042	9-Jan-02	GS0202340	10100069	< 0.4	< 0.09	0.19 ± 0.06	1.5 ± 0.6	0.8 ± 0.6
NAES043	10-Jan-02	GS0202341	10100070	< 0.38	< 0.10	< 0.11	< 1.5	< 1.2
NAES044	9-Jan-02	GS0202342	10100071	0.50 ± 0.13	< 0.11	< 0.11	< 1.4	< 1.1
NAES045	9-Jan-02	GS0202343	10100072	< 0.39	< 0.10	0.14 ± 0.05	1.1 ± 0.5	< 1.3
NAES046	9-Jan-02	GS0202344	10100073	< 0.4	< 0.10	0.56 ± 0.09	< 1.3	< 1.3
NAES047	9-Jan-02	GS0202345	10100074	< 0.39	< 0.10	0.62 ± 0.10	1.6 ± 0.6	< 1.3

Table B-3. BOMARC Soil Sample γ-Spectroscopy Analysis

Measurement Location Identifier	Soil Collection Date	Sample Identification		Gamma Spectroscopy Analytical Results Activity Concentration (pCi/g-dried)				
		Base	AFIERA SDRR	Ac-228	Am-241	Cs-137	K-40	Th-234
NAES048	9-Jan-02	GS0202346	10100075	< 0.47	< 0.19	0.77 ± 0.11	< 1.4	< 1.9
NAES049	9-Jan-02	GS0202347	10100076	< 0.44	< 0.18	< 0.14	< 1.3	< 1.8
NAES050	9-Jan-02	GS0202348	10100077	< 0.49	< 0.20	0.09 ± 0.07	< 1.6	< 2.0
NAES051	9-Jan-02	GS0202349	10100078	< 0.52	< 0.20	< 0.14	< 1.3	< 2.0
NAES052	9-Jan-02	GS0202350	10100079	< 0.54	< 0.20	0.15 ± 0.06	4.0 ± 1.0	< 2.0
NAES053	9-Jan-02	GS0202351	10100080	< 0.45	< 0.19	1.01 ± 0.12	< 1.4	< 1.9
NAES054	9-Jan-02	GS0202352	10100081	< 0.45	< 0.19	0.79 ± 0.11	< 1.4	< 1.9
NAES055	9-Jan-02	GS0202353	10100082	< 0.48	< 0.20	0.72 ± 0.11	< 1.3	< 1.9
NAES056	9-Jan-02	GS0202354	10100083	< 0.47	< 0.19	0.22 ± 0.07	< 1.4	< 1.9
NAES057	9-Jan-02	GS0202355	10100084	< 0.47	< 0.19	0.79 ± 0.11	< 1.4	< 1.9
NAES058	9-Jan-02	GS0202356	10100085	< 0.39	< 0.14	0.21 ± 0.06	< 1.2	< 1.3
NAES059	9-Jan-02	GS0202357	10100086	< 0.38	< 0.13	0.50 ± 0.08	< 0.94	< 1.3
NAES060	9-Jan-02	GS0202358	10100087	< 0.32	< 0.13	0.07 ± 0.05	1.0 ± 0.5	< 1.2
NAES061	9-Jan-02	GS0202359	10100088	< 0.47	< 0.18	< 0.13	< 1.4	< 1.8
NAES062	9-Jan-02	GS0202360	10100089	< 0.48	< 0.19	< 0.13	< 1.4	< 1.8
NAES063	9-Jan-02	GS0202361	10100090	< 0.46	< 0.19	0.15 ± 0.07	< 1.5	< 1.8
NAES064	9-Jan-02	GS0202362	10100091	< 0.47	< 0.18	< 0.14	< 1.2	< 1.8
NAES065	9-Jan-02	GS0202363	10100092	< 0.45	< 0.19	< 0.13	< 1.5	< 1.9
NAES066	10-Jan-02	GS0202364	10100093	< 0.46	< 0.19	< 0.13	0.7 ± 0.6	< 1.9
NAES067	10-Jan-02	GS0202365	10100094	< 0.47	< 0.19	< 0.14	< 1.3	< 1.8
NAES068	10-Jan-02	GS0202366	10100095	< 0.48	< 0.20	0.08 ± 0.06	0.8 ± 0.6	< 1.9
NAES069	10-Jan-02	GS0202367	10100096	< 0.49	< 0.19	< 0.13	< 1.4	< 1.9
NAES070	10-Jan-02	GS0202368	10100097	< 0.55	< 0.20	0.16 ± 0.07	0.7 ± 0.7	< 2.0
NAES071	10-Jan-02	GS0202369	10100098	< 0.42	< 0.14	0.22 ± 0.06	0.7 ± 0.5	< 1.4
NAES072	10-Jan-02	GS0202370	10100099	< 0.35	< 0.13	0.12 ± 0.05	< 0.11	< 1.2

Table B-3. BOMARC Soil Sample γ-Spectroscopy Analysis

Measurement Location Identifier	Soil Collection Date	Sample Identification		Gamma Spectroscopy Analytical Results Activity Concentration (pCi/g-dried)				
		Base	AFIERA SDRR	Ac-228	Am-241	Cs-137	K-40	Th-234
NAES073	10-Jan-02	GS0202371	10100100	< 0.35	< 0.10	0.19 ± 0.05	1.6 ± 0.5	< 1.1
NAES074	10-Jan-02	GS0202372	10100101	< 0.33	< 0.10	0.14 ± 0.05	1.7 ± 0.5	< 1.0
NAES075	10-Jan-02	GS0202373	10100102	< 0.33	< 0.10	0.11 ± 0.05	< 1.0	< 1.1
NAES076	10-Jan-02	GS0202374	10100103	< 0.32	< 0.09	0.14 ± 0.05	1.6 ± 0.5	< 1.1
NAES077	10-Jan-02	GS0202375	10100104	< 0.31	< 0.10	0.12 ± 0.05	0.8 ± 0.4	< 1.1
NAES078	10-Jan-02	GS0202376	10100105	< 0.33	< 0.10	0.22 ± 0.06	1.5 ± 0.5	< 1.1
NAES079	10-Jan-02	GS0202377	10100106	0.58 ± 0.12	< 0.11	< 0.08	1.3 ± 0.5	< 1.1
NAES080	10-Jan-02	GS0202378	10100107	< 0.39	< 0.10	0.16 ± 0.05	2.2 ± 0.6	< 1.1
NAES081	10-Jan-02	GS0202379	10100108	< 0.33	< 0.09	0.10 ± 0.04	0.9 ± 0.4	< 1.0
NAES082	10-Jan-02	GS0202380	10100109	0.30 ± 0.10	< 0.09	< 0.07	1.1 ± 0.4	< 1.0
NAES083	10-Jan-02	GS0202381	10100110	< 0.42	< 0.16	< 0.10	1.1 ± 0.6	< 1.1
NAES084	10-Jan-02	GS0202382	10100111	< 0.41	< 0.14	0.13 ± 0.05	0.7 ± 0.6	< 1.3
NAES085	10-Jan-02	GS0202383	10100112	< 0.43	< 0.10	< 0.12	1.5 ± 0.6	< 1.3
NAES086	10-Jan-02	GS0202384	10100113	< 0.43	< 0.10	0.16 ± 0.06	1.4 ± 0.6	< 1.3
NAES087	10-Jan-02	GS0202385	10100114	< 0.38	< 0.10	< 0.11	1.3 ± 0.5	< 1.2
NAES088	10-Jan-02	GS0202386	10100115	< 0.39	< 0.10	0.12 ± 0.06	1.0 ± 0.6	< 1.3
NAES089	10-Jan-02	GS0202387	10100116	< 0.39	< 0.12	< 0.11	< 1.4	< 1.5
NAES090	10-Jan-02	GS0202388	10100117	< 0.42	< 0.10	0.06 ± 0.05	< 1.3	< 1.2
NAES091	10-Jan-02	GS0202389	10100118	< 0.44	< 0.10	0.07 ± 0.05	1.6 ± 0.7	< 1.3
NAES092	10-Jan-02	GS0202390	10100119	< 0.42	< 0.09	0.21 ± 0.07	1.4 ± 0.6	< 1.3
NAES093	10-Jan-02	GS0202391	10100120	< 0.35	< 0.09	< 0.10	1.8 ± 0.6	< 1.2
NAES094	10-Jan-02	GS0202392	10100121	< 0.43	< 0.10	0.22 ± 0.06	2.9 ± 0.7	< 1.3

Table B-3. BOMARC Soil Sample γ-Spectroscopy Analysis

Measurement Location Identifier	Soil Collection Location	Sample Identification		Gamma Spectroscopy Analytical Results Activity Concentration (pCi/g-dried)				
		Base	AFIERA SDRR	Ac-228	Am-241	Cs-137	K-40	Th-234
RH003	Soil	GS0202548	10200529	< 0.33	< 0.10	< 0.10	0.6 ± 0.5	< 1.1
RH004	Gravel	GS0202549	10200530	< 0.32	< 0.09	< 0.08	3.3 ± 0.8	< 1.1
RH005	Gravel	GS0202550	10200531	< 0.33	< 0.09	< 0.08	3.7 ± 0.8	< 1.0
RH006	Soil	GS0202551	10200532	< 0.31	< 0.09	0.51 ± 0.07	< 0.94	< 1.1
RH007	Gravel	GS0202552	10200533	< 0.33	< 0.09	< 0.08	< 0.86	< 1.0
RH008	Gravel	GS0202553	10200534	0.34 ± 0.11	< 0.10	0.42 ± 0.07	< 0.90	0.7 ± 0.6
RH009	Soil	GS0202554	10200535	< 0.32	< 0.10	0.43 ± 0.07	< 1.0	< 1.0
RH010	Gravel	GS0202555	10200536	< 0.31	< 0.10	< 0.08	3.1 ± 0.7	< 1.0
RH011	Gravel	GS0202556	10200537	< 0.33	< 0.09	< 0.07	3.8 ± 0.8	0.9 ± 0.6
RH012	Soil	GS0202557	10200538	< 0.29	< 0.08	0.25 ± 0.06	< 1.0	< 1.0
RH013	Gravel	GS0202558	10200539	< 0.50	< 0.19	< 0.12	3.3 ± 0.9	< 1.9
RH014	Gravel	GS0202559	10200540	< 0.49	< 0.19	< 0.13	2.5 ± 0.9	< 1.9
RH015	Soil	GS0202560	10200541	< 0.49	< 0.20	0.17 ± 0.07	< 1.5	< 1.9
RH016	Gravel	GS0202561	10200542	< 0.45	< 0.18	< 0.13	2.6 ± 0.8	< 1.8
RH017	Gravel	GS0202562	10200543	0.38 ± 0.15	< 0.19	< 0.13	2.5 ± 0.9	< 1.8
RH018	Soil	GS0202563	10200544	< 0.49	< 0.19	< 0.14	< 1.3	< 1.9
RH019	Gravel	GS0202564	10200545	< 0.50	< 0.19	< 0.13	1.2 ± 0.8	< 1.9
RH020	Gravel	GS0202565	10200546	< 0.50	< 0.20	< 0.13	1.6 ± 0.8	1.4 ± 1.1
RH021	Soil	GS0202566	10200547	< 0.49	< 0.20	< 0.13	< 1.5	< 2.0
RH022	Gravel	GS0202567	10200548	0.55 ± 0.17	< 0.20	< 0.13	< 1.7	< 2.0
RH023	Gravel	GS0202568	10200549	< 0.41	< 0.10	< 0.09	< 1.9	< 1.1
RH024	Soil	GS0202569	10200550	< 0.38	< 0.09	0.48 ± 0.09	0.7 ± 0.6	< 1.1
RH025	Gravel	GS0202570	10200551	0.73 ± 0.14	< 0.10	< 0.10	< 1.5	< 1.2
RH026	Soil	GS0202571	10200552	< 0.37	< 0.10	0.32 ± 0.08	< 1.5	< 1.1
RH027	Soil	GS0202572	10200553	< 0.36	< 0.10	0.42 ± 0.08	< 1.4	0.7 ± 0.6
				Uncertainty Levels at the 95 % Confidence Level				

Table B-4. BOMARC Soil Sample α-Spectroscopy Analysis

Measurement Location Identifier	Sample Identification		Alpha Spectroscopy Pu-239 + 240 Activity Concentration (fCi/g-dried)						
	Base	AFIERA SDRR	Primary Sample			AFIERA/SDRR or Framatome Duplicate			
			Value	MDC	Recovery	Value	MDC	Recovery	Identifier
QA/QC	NA	NA	NA	NA	NA				
RH001	GS0202393	10100122	20 ± 20	20	0.98 ± 0.07				
RH002	GS0202394	10100123	10 ± 17	34	0.91 ± 0.07				
NAES001	GS0202299	10100028	(- 6 ± 7)	60	0.88 ± 0.07	(- 6 ± 7)	84	0.82 ± 0.06	30200234
NAES002	GS0202300	10100029	(- 7 ± 8)	70	0.82 ± 0.06	2 ± 3	4	NR	L2523-01
NAES003	GS0202301	10100030	20 ± 30	50	1.00 ± 0.07				
NAES004	GS0202302	10100031	20 ± 40	80	0.79 ± 0.06				
NAES005	GS0202303	10100032	20 ± 30	60	0.93 ± 0.07				
NAES006	GS0202304	10100033	10 ± 30	60	0.86 ± 0.07				
NAES007	GS0202305	10100034	(- 6 ± 7)	62	0.84 ± 0.06				
NAES008	GS0202306	10100035	10 ± 20	60	0.84 ± 0.07				
NAES009	GS0202307	10100036	7 ± 18	46	1.00 ± 0.08				
NAES010	GS0202308	10100037	10 ± 30	70	0.82 ± 0.06				
NAES011	GS0202309	10100038	20 ± 40	70	0.75 ± 0.06	(- 7 ± 8)	68	0.78 ± 0.06	30200236
NAES012	GS0202310	10100039	(-7 ± 8)	71	0.80 ± 0.06	5 ± 4	4	NR	L2523-02
NAES013	GS0202311	10100040	(- 4 ± 6)	60	0.85 ± 0.06				
NAES014	GS0202312	10100041	10 ± 30	90	0.69 ± 0.05				
NAES015	GS0202313	10100042	40 ± 40	70	0.74 ± 0.06				
NAES016	GS0202314	10100043	10 ± 30	60	0.89 ± 0.07				
NAES017	GS0202315	10100044	(- 7 ± 8)	70	0.82 ± 0.07				
NAES018	GS0202316	10100045	(- 7 ± 8)	70	0.76 ± 0.06				
NAES019	GS0202317	10100046	7 ± 18	48	0.98 ± 0.08				
NAES020	GS0202318	10100047	10 ± 20	50	0.80 ± 0.06				
NAES021	GS0202319	10100048	0 ± 20	80	0.70 ± 0.06	(- 5 ± 7)	65	0.72 ± 0.06	30200238
NAES022	GS0202320	10100049	10 ± 20	50	0.80 ± 0.06	(-0.5 ± 0.4)	4.2	NR	L2523-03

Table B-4. BOMARC Soil Sample α-Spectroscopy Analysis

Measurement Location Identifier	Sample Identification		Alpha Spectroscopy Pu-239 + 240 Activity Concentration (fCi/g-dried)						
			Primary Sample			AFIERA/SDRR or Framatome Duplicate			
	Base	AFIERA SDRR	Value	MDC	Recovery	Value	MDC	Recovery	Identifier
NAES023	GS0202321	10100050	30 ± 30	30	0.87 ± 0.07				
NAES024	GS0202322	10100051	6 ± 17	43	0.85 ± 0.06				
NAES025	GS0202323	10100052	10 ± 30	60	0.87 ± 0.07				
NAES026	GS0202324	10100053	10 ± 20	30	0.81 ± 0.06				
NAES027	GS0202325	10100054	30 ± 30	50	0.86 ± 0.07				
NAES028	GS0202326	10100055	(- 2 ± 4)	42	0.93 ± 0.07				
NAES029	GS0202327	10100056	20 ± 30	30	0.93 ± 0.08				
NAES030	GS0202328	10100057	20 ± 30	50	0.89 ± 0.07				
NAES031	GS0202329	10100058	0 ± 14	50	0.86 ± 0.06	7 ± 17	40	0.89 ± 0.06	30200240
NAES032	GS0202330	10100059	20 ± 20	40	0.87 ± 0.06	5 ± 5	4	NR	L2523-04
NAES033	GS0202331	10100060	11 ± 16	15	0.96 ± 0.06				
NAES034	GS0202332	10100061	30 ± 30	20	0.72 ± 0.05				
NAES035	GS0202333	10100062	(- 4 ± 6)	45	0.84 ± 0.06				
NAES036	GS0202334	10100063	30 ± 30	20	0.87 ± 0.06				
NAES037	GS0202335	10100064	30 ± 30	50	0.67 ± 0.05				
NAES038	GS0202336	10100065	5 ± 16	44	0.67 ± 0.05				
NAES039	GS0202337	10100066	30 ± 30	20	0.94 ± 0.07				
NAES040	GS0202338	10100067	4 ± 13	36	0.97 ± 0.07				
NAES041	GS0202339	10100068	10 ± 20	40	0.72 ± 0.05	0 ± 15	52	0.81 ± 0.06	30200242
NAES042	GS0202340	10100069	11 ± 16	15	0.96 ± 0.06	3 ± 4	6	NR	L2523-05
NAES043	GS0202341	10100070	13 ± 18	18	0.73 ± 0.05				
NAES044	GS0202342	10100071	2 ± 17	57	0.66 ± 0.05				
NAES045	GS0202343	10100072	20 ± 20	20	0.69 ± 0.05				
NAES046	GS0202344	10100073	80 ± 50	40	0.80 ± 0.06				
NAES047	GS0202345	10100074	70 ± 50	50	0.56 ± 0.04				

Table B-4. BOMARC Soil Sample α-Spectroscopy Analysis

Measurement Location Identifier	Sample Identification		Alpha Spectroscopy Pu-239 + 240 Activity Concentration (fCi/g-dried)						
	Base	AFIERA SDRR	Primary Sample			AFIERA/SDRR or Framatome Duplicate			
			Value	MDC	Recovery	Value	MDC	Recovery	Identifier
NAES048	GS0202346	10100075	40 ± 30	20	0.91 ± 0.07				
NAES049	GS0202347	10100076	20 ± 30	40	0.78 ± 0.06				
NAES050	GS0202348	10100077	2 ± 14	46	0.82 ± 0.06				
NAES051	GS0202349	10100078	0 ± 15	53	0.80 ± 0.06	2 ± 14	47	0.77 ± 0.05	30200451
NAES052	GS0202350	10100079	20 ± 20	40	0.85 ± 0.06	4 ± 5	5	NR	L2523-06
NAES053	GS0202351	10100080	60 ± 40	20	0.82 ± 0.05				
NAES054	GS0202352	10100081	30 ± 30	20	0.79 ± 0.05				
NAES055	GS0202353	10100082	30 ± 30	50	0.84 ± 0.06				
NAES056	GS0202354	10100083	40 ± 30	20	0.91 ± 0.07				
NAES057	GS0202355	10100084	20 ± 20	40	0.87 ± 0.06				
NAES058	GS0202356	10100085	30 ± 30	40	0.77 ± 0.05				
NAES059	GS0202357	10100086	50 ± 40	40	0.93 ± 0.07				
NAES060	GS0202358	10100087	11 ± 16	15	0.91 ± 0.06				
NAES061	GS0202359	10100088	0 ± 14	49	0.88 ± 0.06	7 ± 16	39	0.91 ± 0.06	30200246
NAES062	GS0202360	10100089	4 ± 12	33	0.98 ± 0.07	(-0.3 ± 0.3)	4.4	NR	L2523-07
NAES063	GS0202361	10100090	11 ± 15	15	1.00 ± 0.07				
NAES064	GS0202362	10100091	5 ± 11	15	0.87 ± 0.06				
NAES065	GS0202363	10100092	2 ± 13	41	0.91 ± 0.06				
NAES066	GS0202364	10100093	5 ± 11	15	0.97 ± 0.06				
NAES067	GS0202365	10100094	20 ± 20	30	0.97 ± 0.07				
NAES068	GS0202366	10100095	20 ± 20	40	0.73 ± 0.05				
NAES069	GS0202367	10100096	10 ± 20	20	0.76 ± 0.06				
NAES070	GS0202368	10100097	10 ± 16	34	1.02 ± 0.07				
NAES071	GS0202369	10100098	20 ± 30	50	0.94 ± 0.07	(-4 ± 5)	41	0.88 ± 0.06	30200248
NAES072	GS0202370	10100099	(-2 ± 4)	34	0.96 ± 0.07	1 ± 2	3	NR	L2524-08

Table B-4. BOMARC Soil Sample α-Spectroscopy Analysis

Measurement Location Identifier	Sample Identification		Alpha Spectroscopy Pu-239 + 240 Activity Concentration (fCi/g-dried)						
			Primary Sample			AFIERA/SDRR or Framatome Duplicate			
	Base	AFIERA SDRR	Value	MDC	Recovery	Value	MDC	Recovery	Identifier
NAES073	GS0202371	10100100	20 ± 20	20	0.76 ± 0.05				
NAES074	GS0202372	10100101	6 ± 12	17	0.75 ± 0.05				
NAES075	GS0202373	10100102	(-2 ± 4)	37	0.85 ± 0.06				
NAES076	GS0202374	10100103	(-2 ± 4)	33	0.89 ± 0.06				
NAES077	GS0202375	10100104	4 ± 13	36	0.88 ± 0.06				
NAES078	GS0202376	10100105	(-2 ± 4)	35	0.85 ± 0.06				
NAES079	GS0202377	10100106	6 ± 11	16	0.90 ± 0.06				
NAES080	GS0202378	10100107	12 ± 16	16	0.90 ± 0.06				
NAES081	GS0202379	10100108	30 ± 30	40	0.79 ± 0.06	10 ± 20	50	0.83 ± 0.06	30200250
NAES082	GS0202380	10100109	30 ± 30	20	0.75 ± 0.05	(-0.4 ± 0.3)	3.8	NR	L2524-09
NAES083	GS0202381	10100110	10 ± 18	40	0.76 ± 0.07				
NAES084	GS0202382	10100111	20 ± 20	40	0.92 ± 0.06				
NAES085	GS0202383	10100112	7 ± 14	19	0.79 ± 0.06				
NAES086	GS0202384	10100113	10 ± 20	40	0.74 ± 0.06				
NAES087	GS0202385	10100114	20 ± 30	40	0.74 ± 0.05				
NAES088	GS0202386	10100115	12 ± 17	16	0.99 ± 0.07				
NAES089	GS0202387	10100116	10 ± 17	35	0.99 ± 0.07				
NAES090	GS0202388	10100117	30 ± 30	20	0.80 ± 0.05				
NAES091	GS0202389	10100118	0 ± 14	52	0.82 ± 0.06	8 ± 18	45	0.81 ± 0.06	30200252
NAES092	GS0202390	10100119	(-2 ± 5)	39	0.81 ± 0.06	3 ± 4	5	NR	L2524-10
NAES093	GS0202391	10100120	12 ± 17	17	0.77 ± 0.05				
NAES094	GS0202392	10100121	2 ± 13	41	0.91 ± 0.06				

Table B-4. BOMARC Soil Sample α-Spectroscopy Analysis

Measurement Location Identifier	Sample Identification		Alpha Spectroscopy Pu-239 + 240 Activity Concentration (fCi/g-dried)						
			Primary Sample			AFIERA/SDRR or Framatome Duplicate			
	Base	AFIERA SDRR	Value	MDC	Recovery	Value	MDC	Recovery	Identifier
RH003	GS0202548	10200529	(-0.6 ± 0.6)	14.2	0.93 ± 0.07	3 ± 6	8	0.89 ± 0.07	30200639
RH004	GS0202549	10200530	2 ± 3	15	0.97 ± 0.07				
RH005	GS0202550	10200531	2 ± 6	14	0.93 ± 0.07				
RH006	GS0202551	10200532	3 ± 3	8	0.78 ± 0.06				
RH007	GS0202552	10200533	0.0 ± 0.4	7.6	0.90 ± 0.07				
RH008	GS0202553	10200534	3 ± 3	8	0.95 ± 0.07				
RH009	GS0202554	10200535	0 ± 0.2	7.7	0.91 ± 0.07				
RH010	GS0202555	10200536	6 ± 9	9	0.81 ± 0.06				
RH011	GS0202556	10200537	3 ± 6	8	0.94 ± 0.07				
RH012	GS0202557	10200538	2 ± 6	17	0.85 ± 0.07	6.1 ± 1.4	1.7	NR	L2603-01
RH013	GS0202558	10200539	(-0.6 ± 0.6)	14.2	0.95 ± 0.07	0.0 ± 0.3	8	0.84 ± 0.07	30200641
RH014	GS0202559	10200540	0.0 ± 0.2	8.8	0.87 ± 0.07				
RH015	GS0202560	10200541	2 ± 6	16	0.86 ± 0.06				
RH016	GS0202561	10200542	3 ± 4	19	0.88 ± 0.07				
RH017	GS0202562	10200543	6 ± 9	8	0.82 ± 0.06				
RH018	GS0202563	10200544	3 ± 3	9	0.86 ± 0.07				
RH019	GS0202564	10200545	6 ± 8	8	0.86 ± 0.07				
RH020	GS0202565	10200546	3 ± 7	9	0.75 ± 0.06				
RH021	GS0202566	10200547	3 ± 6	9	0.87 ± 0.07				
RH022	GS0202567	10200548	(-0.7 ± 1.4)	15.6	0.90 ± 0.07	1.4 ± 1.0	1.9	NR	L2603-02
RH023	GS0202568	10200549	3 ± 3	8	0.83 ± 0.07	6 ± 8	8	0.94 ± 0.07	30200643
RH024	GS0202569	10200550	3 ± 3	9	0.89 ± 0.07				
RH025	GS0202570	10200551	(-0.8 ± 1.6)	18.4	0.72 ± 0.06				
RH026	GS0202571	10200552	2 ± 3	14	0.85 ± 0.06				
RH027	GS0202572	10200553	9 ± 10	8	0.82 ± 0.06				
NR = Not Reported		Uncertainty Levels at the 95 % Confidence Level					Framatome Results are Bordered		

Appendix C

Calibration Logs and Hot-Spot Calculations

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Institute for Environment, Safety and Occupational Health Risk Analysis

Calibration Data Sheet

Date 4-Jan-02

Due 4-Jul-02

Instrumentation Data

MFG.	Model	Serial No.
Ludlum	2221	169214

Detector Data

MFG.	Model	Serial No.
Bicron	G-5 FIDLER	B603M

Calibrated Check Sources

Isotope	Serial #	Cal date
Am-241	2Q156	1-Apr-02

Pulser

MFG.	Model	Serial No.
Ludlum	500	102951

Sensitivity/Window

Emission	Sensitivity	Window
Gamma	12 mV	22 mV

Calibration Conditions

Temperature	Humidity	Location
64.2	28.50%	ICF/Bldg 1193

Electronics Package

Rate meter Check

Range Multiplier	Reference Point	As found Response	Corrected Response	% error
X1000	400000	400000	400000	0.00%
X1000	100000	100000	100000	0.00%
X100	40000	40000	40000	0.00%
X100	10000	10000	10000	0.00%
X10	4000	4000	4000	0.00%
X10	1000	1000	1000	0.00%
X1	400	400	400	0.00%
X1	100	100	100	0.00%

Scaler Check

Range Multiplier	Reference Point	As found Response	Corrected Response	% error
X1000	400000	396343	396343	-0.91%
X1000	100000	98980	98980	-1.02%
X100	40000	39644	39644	-0.89%
X100	10000	9874	9874	-1.26%
X10	4000	3961	3961	-0.98%
X10	1000	988	988	-1.20%
X1	400	397	397	-0.75%
X1	100	98	98	-2.00%

Calibrated by:
Bryan D. Blasy, SSgt
Health Physics Technician

CRYSTAL RESOLUTION

FIDLER

60 KeV (Am-241)	Peak Channel	LHM (Channel)	RHM (Channel)
	411	354	470

% FWHM= **28.22%**

High Voltage Plateau

FIDLER

60 KeV (Am-241)	HV	CPM
	900	104208

Max Reading= 104208

Final HV= 900

Statistical Reliability Check

FIDLER

60 Kev (Am-241)	Source Counts
1	103580
2	103803
3	103552
4	104512
5	104207
6	104270
7	103639
8	104308
9	104103
10	104390
Average=	**104036.4**
Std. Dev.=	**360.3162808**
Chi^2=	**11.23116909**

FIDLER Program

Distance (cm)	CPM (60 KeV)
10 Minute Background	5382.00
0	104092
20	57094.00
40	20404
50	12541
60	8090
80	3827
100	2265

Calibrated by:
Bryan D. Blasy, SSgt
Health Physics Technician

Institute for
Environment, Safety and Occupational Health
Risk
Analysis

Calibration Data Sheet

Date 2-Jan-02
Due 1-Jul-02

Instrumentation Data

MFG.	Model	Serial No.
Ludlum	**2360**	**145487**

Detector Data

MFG.	Model	Serial No.
Ludlum	**43-89**	**PR154738**

Calibrated Check Sources

Isotope	Serial #	Cal date
Pu-239	k-827	2-Mar-99
Tc-99	514-38-2	2-Jan-96
Sr-90	221-1-6	6-Jan-88

Pulsar

MFG.	Model	Serial No.
Ludlum	500	48124

Sensitivity/Window

Isotope	Sensitivity	Window
Alpha	120 mV	n/a
Beta	3.5 mV	30 mV
Gamma	n/a	n/a

Calibration Conditions

Temperature	Humidity	Location
70.9	22.00%	ICF/Bldg 1193

Final Voltage 775

ELECTRONICS PACKAGE

Range Multiplier	Reference Point	As found Response	Corrected Response	% error (A)	%error (B)	One minute count @ 40000 CPM
X1000	400Kcpm	400K	400K	0	0	39881
X1000	100Kcpm	100K	100K	0	0	
X100	40Kcpm	40K	40K	0	0	
X100	10Kcpm	10K	10K	0	0	
X10	4Kcpm	4K	4K	0	0	
X10	1Kcpm	1K	1k	0	0	
X1	400cpm	400	400	0	0	
	100cpm	100	100	0	0	

Efficiency
2pi

	Pu-239	Tc-99	Sr-90
Heal	22.26	17.54	46.21
Center	21.21	15.83	45.84
Toe	19.35	17.47	48.37
Average	**20.94**	**16.95**	**46.81**

Calibrated by:
SSgt Bryan D. Blasy
Health Physics Technician
4/3/2002

High Voltage

HV	Back Ground
775	0/212
800	0/247
825	2/311

Efficiency

Pu-239	DPM		Alpha
	3.23E+03	**Heal**	719
		Center	685
		Toe	625

Tc-99	DPM		Beta
	2.22E+05	**Heal**	38935
		Center	35139
		Toe	38781

Sr-90	DPM		Beta
	2.26E+04	**Heal**	10443
		Center	10360
		Toe	10932

Calibrated by:
SSgt Bryan D. Blasy
Health Physics Technician
4/3/2002

Institute for Environment, Safety and Occupational Health Risk Analysis

Calibration Data Sheet

Date 2-Jan-02
Due 1-Jul-02

Instrumentation Data

MFG.	*Model*	*Serial No.*
Ludlum	**2360**	**145470**

Detector Data

MFG.	*Model*	*Serial No.*
Ludlum	**43-89**	**PR153659**

Calibrated Check Sources

Isotope	*Serial #*	*Cal date*
Pu-239	k-827	2-Mar-89
Tc-99	514-38-1	2-Jan-96
Sr-90	221-1-6	6-Jan-88

Pulsar

MFG.	*Model*	*Serial No.*
Ludlum	500	48124

Sensitivity/Window

Isotope	Sensitivity	Window
Alpha	120 mV	n/a
Beta	3.5 mV	30 mV
Gamma	n/a	n/a

Calibration Conditions

Temperature	Humidity	Location
67	28.30%	ICF/Bldg 1193

Final Voltage 800

ELECTRONICS PACKAGE

Range Multiplier	Reference Point	As found Response	Corrected Response	% error (A)	%error (B)	One minute count @ 40000 CPM
X1000	400Kcpm	400K	400K	0	0	39903
X1000	100Kcpm	100K	100K	0	0	
X100	40Kcpm	40K	40K	0	0	
X100	10Kcpm	10K	10K	0	0	
X10	4Kcpm	4K	4K	0	0	
X10	1Kcpm	1K	1k	0	0	
X1	400cpm	400	400	0	0	
x1	100cmp	100	100	0	0	

Efficiency
2pi

	<u>Pu-239</u> 35%	<u>Tc-99</u> 20%	<u>Sr-90</u> 35%
<u>Heal</u>	22.01	16.81	50.00
<u>Center</u>	20.62	15.04	46.92
<u>Toe</u>	21.61	14.35	45.14
<u>Average</u>	21.41	15.40	47.35

Calibrated by:
SSgt Bryan D. Blasy
Health Physics Technician
4/3/2002

High Voltage

HV	BKG
775	0/202
800	0/243
825	0/341

Efficiency

Pu-239	DPM		Alpha
	3.23E+03	**Heal**	711
		Center	666
		Toe	698

Tc-99	DPM		Beta
	2.22E+05	**Heal**	37312
		Center	33396
		Toe	31852

Sr-90	DPM		Beta
	2.26E+04	**Heal**	11301
		Center	10604
		Toe	10201

Calibrated by:
SSgt Bryan D. Blasy
Health Physics Technician
4/3/2002

Chi-Square Background Check

Date 9-Jan-02 **Time** 0938 Temperature 26 degrees F

Location LAKEHURST N433068.394 E544002.318

1	1804
2	1866
3	1825
4	1774
5	1817
6	1711
7	1794
8	1757
9	1776
10	1775
11	1837
12	1828
13	1814
14	1795
15	1886

Estimated
Standard deviation
42.47

Real
Standard deviation
43.51

Chi-Square
14.69

Confidence level
0.05

Critical Value
25.00

Data passes Chi-Square test

Instrument FIDLER B603M / 2221 Meter 169214

High Voltage: 902
Threshold: 133
Window in: 174

Chi-Square Background Check

Date 10-Jan-02 **Time** 0905 Temperature 36 degrees F

Location LAKEHURST N433068.394 E544002.318

1	1776
2	1769
3	1729
4	1703
5	1737
6	1777
7	1812
8	1676
9	1684
10	1732
11	1738
12	1778
13	1654
14	1765
15	1746

Estimated Standard deviation
41.69

Real Standard deviation
43.88

Chi-Square
15.50

Confidence level
0.05

Critical Value
25.00

Data passes Chi-Square test

Instrument FIDLER B603M / 2221 Meter 169214

High Voltage: 902
Threshold: 133
Window in: 174

Chi-Square Background Check

Date 9-Apr-02 **Time** 0740 Temperature 60 degrees F

Location LAKEHURST N433068.394 E544002.318

1	1428
2	1454
3	1452
4	1433
5	1431
6	1441
7	1405
8	1433
9	1440
10	1490
11	1514
12	1485
13	1433
14	1457
15	1458

Estimated Standard deviation
38.08

Real Standard deviation
27.99

Chi-Square
7.56

Confidence level
0.05

Critical Value
25.00

Data passes Chi-Square test

Instrument FIDLER B603M / 2221 Meter 169214

High Voltage: 902
Threshold: 133
Window in: 174

Chi-Square Background Check

Date 9-Apr-02 **Time** 1130 Temperature 75 degrees F

Location LAKEHURST N433068.394 E544002.318

1	1266
2	1193
3	1198
4	1232
5	1168
6	1252
7	1243
8	1223
9	1214
10	1263
11	1187
12	1237
13	1219
14	1237
15	1253

Estimated
Standard deviation
35.01

Real
Standard deviation
29.15

Chi-Square
9.71

Confidence level
0.05

Critical Value
25.00

Data passes Chi-Square test

Instrument FIDLER B603M / 2221 Meter 169214

High Voltage: 902
Threshold: 133
Window in: 174

Certificate of calibration of gamma reference sources

R 2205

Nuclide	^{241}Am	^{133}Ba	^{137}Cs	^{60}Co	^{88}Y	^{22}Na	^{54}Mn	^{203}Hg	^{57}Co
Colour Code	Red	White	Yellow	Light Green	Black	Cream	Blue	Pink	Dark Green
Source No.	2Q156	2R059	2S380	2U340	2Y554	2X169	2V300	2W517	3T382
Activity, µCi	12.45	10.18	11.50	11.95	12.18	11.22	10.20	23.92	10.05
Accuracy %	5.0	4.8	3.7	1.9	5.0	3.7	3.7	3.0	4.4

Set No 2089 **Activity reference time 1200 GMT on** 1 April 1987

Definitions of the terms used in this certificate and further details of the sources are given in the data sheet provided with each set or replacement source.
This product meets the quality assurance requirements of NRC Regulatory Guide 4.15 for achieving implicit NBS traceability as defined in NCRP58 (1985).

BRITISH CALIBRATION SERVICE
Approval No 0146

Approved Signatory A.G.Tuck

Amersham

Amersham International plc Amersham UK

Table C. Hot-Spot* Code Efficiency Calculations.
[α-Activity, Assuming $^{239+240}Pu$ to ^{241}Am of 5.4]

Date	Energy	Efficiency (α-Activity)		MDC Area (α-Activity)	MDA Point (α-Activity)	Bkgd	Source (0 cm)	Source (50 cm)	K	σ
	keV	$\frac{cpm}{\mu g/m^2}$	$\frac{cpm}{\mu Ci/m^2}$	$\frac{\mu Ci}{m^2}$	μCi	cpm	cpm	cpm	m^2	%
9 Jan 02	60	50	580	0.35	0.14	1804	115775	13739	0.39	1
9 Apr 02	60	43	500	0.36	0.14	1450	100463	13719	0.39	1

* Lawrence Livermore National Laboratory, Hot Spot Health Physics Calibration Codes, Version 8.03, April 1999.

^{241}Am Check Source Activity = 12.45 μCi [Amersham, Source Number 2Q156, 1 Apr 87]
= 12.15 μCi [Decay Corrected]

To calculate $^{239+240}Pu$ Activity, Multiple by 0.84.